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THE EFFECTS OF SHIFTWORK ON
THE PERFORMANCE OF WATCHSTANDERS
AT COAST GUARD COMMUNICATION STATIONS

by

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June 1987

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The Effects of Shiftwork on
the Performance of Watchstanders
at Coast Guard Communication Stations

by

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ABSTRACT

An analysis of a Coast Guard watch system is presented. Current theory and research on shiftwork is documented and discussed to provide background for the analysis. An examination is made to evaluate personnel performance as a function of location within the existing watch schedule. A survey is conducted among watchstanding personnel to examine their opinions and motivations towards the existing watch schedule and relevant factors. Results indicate that there are minor differences between performance during day watches and performance during night watches. Similarly, the study indicated that performance within a given watch declines as time on watch increases for day watches only; this pattern does not hold for night watches.

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I. INTRODUCTION

A. SHIFTWORK

Historically, man has been guided in his daily activity by the circadian rhythms common to most, if not all, living creatures. The physiological and psychological variations of such cycles invariably control the performance levels of human beings [Refs. 1,2: pp. 1-6, 37].

The utilization of shiftwork by industry, military organizations, and other activities has created conflicts with the established circadian rhythms of man. Research has determined that a person's circadian rhythm can be observed by monitoring fluctuations in human physiological systems including body temperature [Ref. 2: pp. 1-6]. Although a causal relationship is not considered to exist between human performance and body temperature, studies have revealed that a parallelism does exist [Ref. 1: pp. 46-49]. Normally, body temperature (and other physical factors) are in rhythm with the higher performance demanded in daytime activities. But shiftwork unnaturally tries to require performance when the human body dictates otherwise (at night, for example). Attempts to control and adjust body temperature and other factors may cause noticeable shifts in performance and activity levels, but such changes occur only over extended periods of time [Ref. 3: pp. 104-106]. Different types of shifts (stabilized or fixed, slowly-rotating, or rapidly-rotating) produce varying levels of performance. This study focuses on the performance within a rapidly-rotating shift system.

B. COAST GUARD COMMUNICATION STATIONS

The U.S. Coast Guard maintains a number of communication stations (COMMSTAs) which operate 24-hours-a-day in support of Coast Guard missions and other activities. Although the particular watch schedule is left to the discretion of each communication station, one common cycle consisting of 12-hour watches is of interest in this study (Figure 1.1). This particular rotation is performed at one Coast Guard COMMSTA (San Francisco).

Although the schedule is comprised of three day watches and three night watches, reference is made (throughout the study) to particular days within the shift cycle. For this reason, each of the different watches is given a designator

(D1 thru N3). 'D' represents a DAY watch; 'N' represents a NIGHT watch. '1' indicates the first watch in the sequence of three watches, '2' the second watch, and '3' the third watch. For example, 'N2' would indicate the second NIGHT watch in the cycle (see Figure 1.1).

DAY	TIME	TIME OFF
1	0600 - 1800 (D1)	-------12 hours
2	0600 - 1800 (D2)	-------12 hours
3	0600 - 1800 (D3)	
4		
5		-------72 hours
6		
7	1800 - 0600 (N1)	-------12 hours
8	1800 - 0600 (N2)	-------12 hours
9	1800 - 0600 (N3)	
10		-------96 hours
11		
12		

(then begin again at Day 1)

Figure 1.1 Watch Schedule Cycle

C. OBJECTIVE

The objective of this thesis is to investigate the performance of the radiowatchstanders throughout the entire watch cycle. Performance levels among the different watches (D1 thru N3) will be measured and compared. This thesis will attempt to answer the following questions:

1. Is watchstander performance dependent on the time of the day (DAY vs. NIGHT) ?

2. Is watchstander performance dependent on the location within the watch itself (first four hours vs. middle four hours vs. last four hours) ?

3. Is watchstander performance dependent on the location within the watch cycle (D1 vs. D2 vs. D3; N1 vs. N2 vs. N3) ?

Specific hypotheses are proposed at the end of Chapter II, following a review of shiftwork literature. Additionally, any variations in the performance levels will be related to fatigue, sleep, and other factors as determined by a survey of COMMSTA watchstanders.

D. ASSUMPTIONS AND LIMITATIONS

Due to its close proximity COMMSTA San Francisco was the only station utilized for the measurement of watchstander performance. The particular measures of performance are assumed to be applicable and reasonable for all Coast Guard COMMSTAs, not only for San Francisco.

While the Coast Guard operates nine communication stations, all of them do not operate on the same watch schedule. Therefore, the results of the survey revealed the opinions of radiomen on a particular watch cycle, and would not necessarily agree nor be comparable with the opinions of those of other watch cycles.

This study focused on Coast Guard communication stations and did not consider the activities of radiomen personnel at district communication centers, onboard ships, or at other Coast Guard units which maintain 24-hour radiowatches.

E. ORGANIZATION OF STUDY

This first chapter is devoted to an introduction to the study of shiftwork at Coast Guard communication stations and the scope of this thesis. Chapter II examines the current research and theory of shiftwork. The third chapter describes the mission, organization, and watchstanding at COMMSTA San Francisco. Chapter IV discusses the methodology of both the performance measurement and the survey. Chapter V is the presentation and analysis of the results from the performance measurement, and the sixth chapter discusses the results of the survey. Chapter VII conducts further analysis of the performance data, and correlates performance with the results of the survey. The last chapter summarizes the findings, and proposes recommendations and further areas of study.

II. SHIFTWORK

A. INTRODUCTION

Three interrelated factors must be synchronized for an individual to successfully cope with shiftwork: circadian rhythms, sleep, and social/domestic life [Ref. 3: p. 97]. Before delving into the matter of shiftwork cycles and their implications, this author will first present a fundamental discussion of human circadian rhythms. This examination will include the existence and measurement of such rhythms, the causes of the rhythms, and resulting human adaptation.

Secondly, a short discussion of shiftwork identifies the different types of shift cycles utilized. The various ways of describing schedules is examined. The performance of shift workers is then examined and equated to the circadian rhythms previously discussed. Task selection, fatigue 'masking', and other factors are related to the measurement of performance.

Next, a brief discussion is made of the effects that shiftwork has on several areas: sleep, social and domestic life, eating habits, health, and the attitudes of the shiftworkers. Lastly, guidelines and recommendations for the design and implementation of shiftwork are presented, along with a descriptive model for shiftwork performance.

B. CIRCADIAN RHYTHMS

Most animals and even many plants have developed internal clocks which guide their day-to-day activities. Entrainment or adaptation of these clocks is most likely established by external rhythms in the environment. Examples are numerous: leaf movements are coordinated with the changes in the available light throughout the day; the lunar cycle causes rhythmic tidal changes which guide the activities of creatures in the intertidal zone; and jungle predators are guided by the cycle of the availability and scarcity of food as dictated by the day/night cycle [Ref. 2: p. 9].

Similarly, the general activities of man are guided by internal clocks. Human circadian rhythms can be physiologically observed by monitoring any of a number of bodily activities. Among the more common are body temperature, heart rate, blood pressure, elimination habits, and urine electrolyte concentrations [Ref. 4: pp. 37-38].

Perhaps the most commonly researched (and most readily available for study) is the measurement of body temperature. In the normal human being, body temperature fluctuates daily across a range of several degrees Fahrenheit [Refs. 5,1: pp. 25, 40]. On the average, minimum temperature is found in the early morning followed by a rise throughout the day with a peak in the early evening hours. [Refs. 5,3: pp. 2, 25]. Figure 2.1 indicates body temperature throughout the day, averaged over a 12-day period [Ref. 6: p. 12].

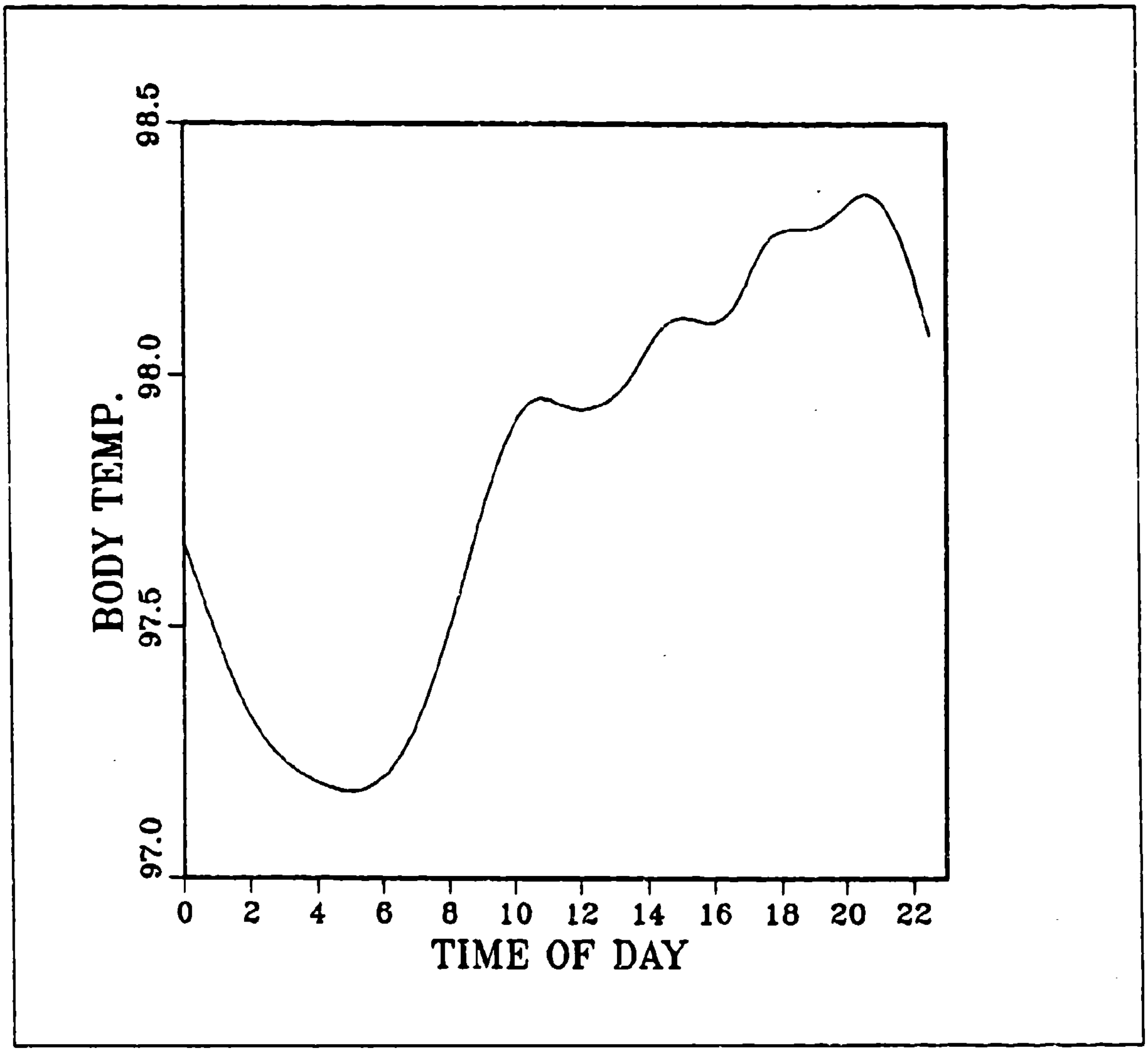


Figure 2.1 Diurnal Body Temperature Cycle

1. **Origin**

There is general disagreement between researchers as to the exact source of the circadian rhythms in humans. Some consider the rhythms to be controlled endogenously, while others support the idea that external events exert influence over the human body's internal oscillators [Ref. 4,7: pp. 39-40, 82]. Compromising, most researchers concur that our circadian rhythms are entrained by the presence of Zeitgebers (periodic cues of the environment) [Ref. 6: p. 7]. These Zeitgebers (German for "time giver") affect man cumulatively. Among the most commonly discussed Zeitgebers are the light-dark, noise-quiet, and feeding-fasting cycles, knowledge of clock time, the activity pattern of society, and the needs of the family [Ref. 8,6,2: pp. 264, 18, 10-11]. The strength of the influences probably determines the effect they have on the adjustment of the circadian rhythm. Multiplicity of the oscillators complicates any analysis due to coupling forces, masking effects and damping [Ref. 9: pp. 27-28].

In general, while the light-dark cycle is the single most powerful influence on the daily rhythms of most plants and animals, it appears that social Zeitgebers have the greatest role in establishing, maintaining, and altering human circadian rhythms [Refs. 10,8: pp. 743, 82]. Examples of these social Zeitgebers are meal time routines, TV scheduling, retail store shopping hours, etc.

2. **Adaptation**

The concept of shiftwork (round-the-clock) appears to be diametrically opposed to the physiological dictates of our circadian rhythms. Before a link between worker performance and circadian rhythm is discussed, this author will note the human body's ability (or reluctance) to adapt its temperature rhythm as previously discussed (Figure 2.1) to a different routine--particularly to a 12-hour phase shift.

A number of studies have placed workers in continuous night work routines for extended periods of time, and the results from this research have been consistent. It was found that the greatest change (or phase shift) in temperature occurred in the first week (most of it in the first few days) [Refs. 11,2,12: pp. 782, 186, 626]. Although temperature changes were found, after weeks of night work a full inversion of body temperature was not realized, only a partial adaptation [Ref. 8: p. 91]. Rather than an inversion, a 'flattening' of the temperature curve was noticed [Refs. 6,2: pp. 9, 186]. Figure 2.2 indicates the temperature shifts for individuals on a 12-hour night shift. The three plots are after 1 day, 6 days, and 12 days of continuous night work. [Ref. 13: p. 871].

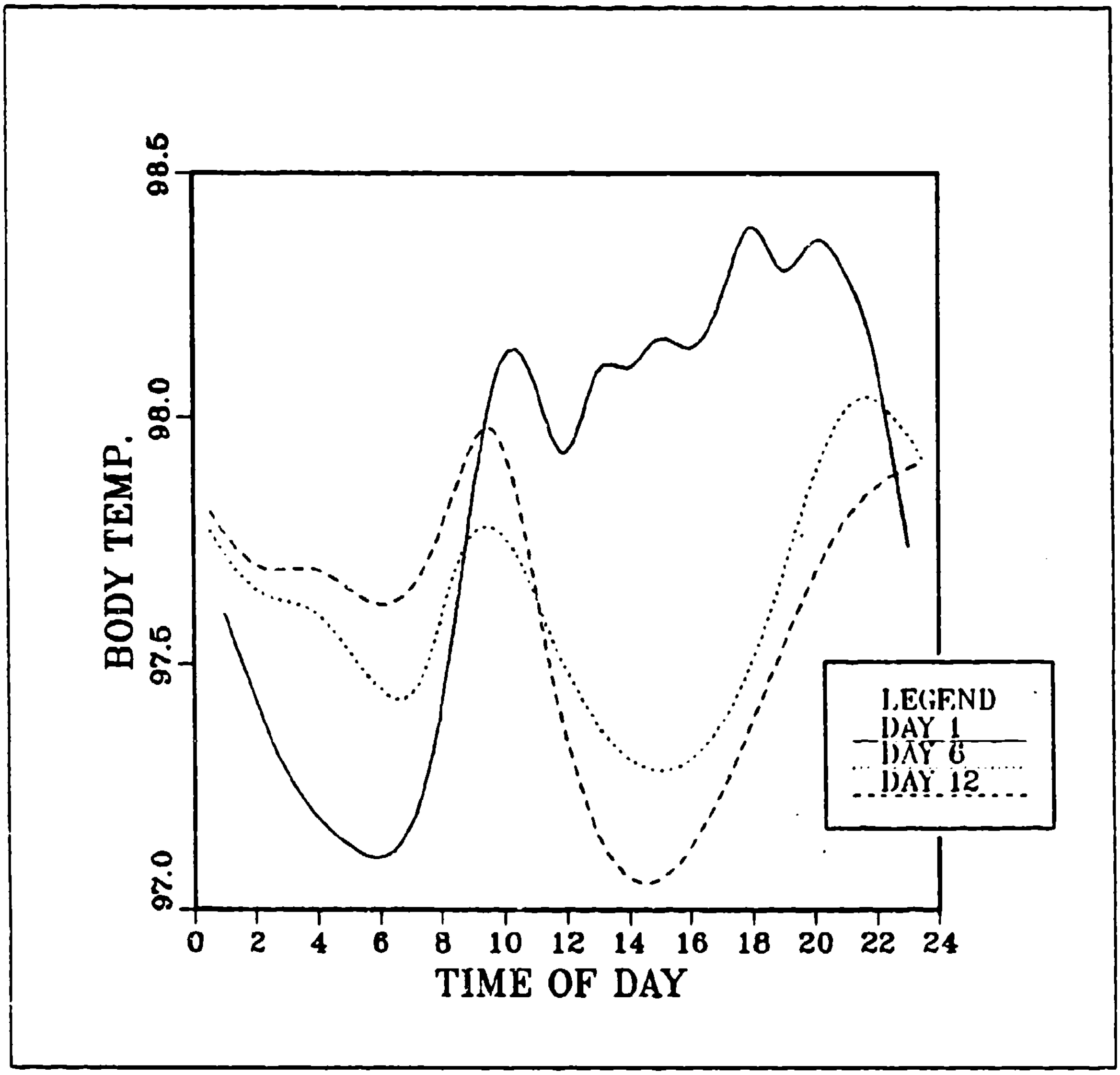


Figure 2.2 Temperature Adaptation for Continuous Night Work

At the end of the night work schedule, body temperature becomes 're-entrained' to the normal routine within several days. The fewer the successive night shifts, the fewer the days required to readjust to a normal diurnal temperature rhythm following the night work [Ref. 11: p. 782].

A major reason for failure to make the 12-hour phase inversion in temperature (even over a long period of night work) may be the failure of workers to adapt their living routine to their work schedule. Despite their night hours of work, most individuals maintain a normal daily routine, especially on days off [Refs. 6,12,8,2: pp. 9,

626, 265, 188]. Bodily functions and social activities are maintained on the day schedule pattern despite the physiological conflicts. These strong Zeitgebers tend to maintain the rhythms in a normal cycle and full adaptation to a night activity schedule is impossible [Refs. 4,8,14: pp. 51, 91, 346].

The slow adaptation of the temperature on night shifts leads to two opposing views on the utilization of night work [Ref. 14: p. 343]:

1) the re-entrainment of physiological rhythms that can be achieved within the conflicting Zeitgeber conditions of night-work is desirable. This argues for a maximum number of consecutive night shifts.

2) the physiological cost of achieving partial re-entrainment (which may be observed as a dissociation of different physiological rhythms due to unequal velocities of re-entrainment) outweighs the desirability of achieving partial re-entrainment. This argues for a minimum number of consecutive night shifts.

The amount of adjustment that occurs is directly related to the rate at which the subjects change shifts. Generally, minimal phase adjustment occurs when one or two shifts of one type are worked prior to changing to another shift type [Ref. 3: p. 101]. Further advantages and disadvantages of permanent or rotating shift schedules will be examined later in this chapter.

Adaptation of circadian rhythms also may depend on individual personality traits. Whether a person is a 'morning' or 'evening' type, or an 'introvert' or an 'extrovert' (as determined by a series of questionaires) may indicate a person's ability to adjust their circadian rhythms to the demands of shiftwork [Ref. 8: p. 270].

C. SHIFTWORK PATTERNS

Shift schedules are quite numerous in type and duration but three primary categories exist. The first is the *permanent* shift. Under this routine an individual works the same shift each day (e.g., day shift 0800-1600). Second is the *rapidly-rotating* shift. In this schedule, the worker has one or two of the same shifts in succession, and then changes to a different time (e.g., Day 1 0800-1600, Day 2 0800-1600, Day 3 1600-2400, Day 4 1600-2400, etc.). This is also termed the 'Continental' or 'Metropolitan' system. Lastly, under the *slowly-rotating* system, an individual maintains the same shift for a set time period (weekly, fortnightly, or monthly) before switching to another shift for a similar length of time [Ref. 3: pp. 101-102].

Besides either being a permanent or rotating shift, several other parameters of shiftwork systems exist. These characteristics include:

- the number of consecutive night shifts.

- start and finish times of shifts.
- duration of shifts.
- distribution of leisure time.
- duration of the shift cycle.
- regularity of the shift system.
- direction of rotation of the shift [Ref. 14: pp. 337-362].

The first two parameters are self-explanatory. *Duration of the shift* occurs in many standard lengths, among which are 4-, 6-, 8-, 10-, and 12-hours. Eight-hour shifts are the most common and most research concerns this duration. *Distribution of leisure time* is described by the length of free time between shifts, and the time of the day and week when the leisure time is available. The *duration of the shift cycle* is the amount of time (both work and days off) until the entire sequence repeats on the same day of the week. *Regularity* is described as "the extent to which operational and other requirements result in shiftworkers deviating from the shift plan" [Ref. 14: p. 362].

Direction of rotation of the shift normally refers to 8-hour (or less) shifts. Individuals may rotate *forward* by working several days of day shift (0800-1600), followed by evening shift (1600-2400), then night shift (0000-0800). Rotation of the shift backwards (or *double-backing*) refers to the sequence running night-to-evening-to-day shifts [Ref. 3: p. 101]. Variations in any of these seven attributes will certainly have an effect on most, if not all, of the consequences of shiftwork as discussed in the following two sections.

D. PERFORMANCE OF SHIFTWORKERS

One of the greatest areas of concern for management when considering shiftwork is that of the performance of the shiftworkers. What effect do shift category, length of shift, and time-of-day have for on-the-job performance? Unfortunately, industries and field studies have minimally examined such productivity and performance [Ref. 22: p. 176].

While in some cases it is easy to collect performance measures, the data may not be accurate because of interdependencies on motivation, working strategies, and contact with the research team. The results may be masked by these stronger relationships [Ref. 9: p. 202]. In the lab, carefully-controlled performance analysis is possible because most, if not all, of the undesirable variables can be removed. Unfortunately, despite the best intentions, actual field studies succumb to

uncontrollable factors such as machine stoppage, flow interruptions, temperature, noise, and illumination levels [Ref. 1: pp. 42-43]. Performance comparison is also difficult between different worker groups due to inabilities to control the factors differentiating the groups: factory conditions, supervisors, maintenance levels, etc. [Ref. 23: p. 2].

1. Performance and Circadian Rhythms

Much attention has been drawn to attempts at linking diurnal variations in performance with circadian rhythms (as measured by body temperature). In fact, some experts feel that the degree of chemical activity in the brain is proportional to temperature. This implies that either the rate of brain activity increases with temperature or that "mental processes are themselves chemical processes" [Ref. 6: p. 4]. Indication by early research of a direct causal relationship between performance and body temperature was later replaced by acknowledgement of only a parallelism between the two. [Refs. 18,9,7: pp. 173, 287, 64]. Evidence for the non-existence of the causal relationship was found in the idea called the *post lunch dip*. With the exception of the post lunch period, worker performance usually follows the body temperature level.

This post lunch dip is defined as a noticeable decrease in performance following the normal noon mealtime. This drop in productivity occurs regardless of whether an actual meal was eaten or not. Most significantly, there is no simultaneous drop in the temperature after lunch [Refs. 1,4: pp. 49-50, 44]. The post lunch dip phenomenon is complex--consisting of exogenous factors (e.g., the 'masking' effect of the ingestion of food [Ref. 2: p. 42]) and endogenous factors (including the effects of circadian rhythms).

A more accepted explanation of the link between body temperature and mental efficiency/performance is the idea of the *Arousal Theory* or the (*Inverted-U Hypothesis*):

> This hypothesis states that for a given task, there is an optimal level of workload or demand that yields the highest level of performance. A departure in either direction will result in a monotonically lower performance level, hence an inverted, U-shaped relationship between task demand and quality of performance [Ref. 24: p. 215].

While the arousal rhythms closely parallels the temperature rhythm, it more readily explains the post lunch dip phenomenon. Performance is poor for low levels of arousal

and for when the person is "over-stimulated or excited." Best performance will occur at moderate arousal levels [Refs. 4,2: pp. 44-45, 40].

Historically, performance has always been considered to be a function of the time of the day, i.e., closely related to a person's circadian rhythm [Ref. 1: p. 44]. Both field studies and laboratory experiments have demonstrated the existence of diurnal variations in performance during shiftwork [Ref. 6: pp. 8-9]. Several studies have indicated the variation of job performance throughout the day. Table 1 lists six particular field studies (the year of publication is in parentheses). Figure 2.3 combines the 24-hour performance curves from the six separate studies [Ref. 9: pp. 283-285]. The y-axis of each individual graph is *performance*. High performance is indicated by a high value of the plot, while low performance, etc. The general trend from Figure 2.3 indicates lower performance during the early morning hours (0200-0600). This decreased productivity, combined with an increase in errors, has been observed during night shifts in many jobs [Ref. 22: p. 177]. The decline in performance on night shifts (for permanent or slowly-rotating systems) is linked to: circadian adjustment factors for the first few nights, and sleep deprivation factors thereafter [Ref. 16: p. 1583].

TABLE 1

PERFORMANCE STUDIES

- speed of answering switchboards (1949)
- error frequency in reading gas meters (1953)
- frequency of nodding off while driving (1955)
- speed of joining threads (spinners) (1967)
- frequency of train drivers missing warning signals (1974)
- frequency of minor accidents in a hospital (1978)

[from Ref. 9 : pp. 283-285]

Overall rhythms in productivity are further compounded by the type of task being performed. The information-processing requirements of the work affects the

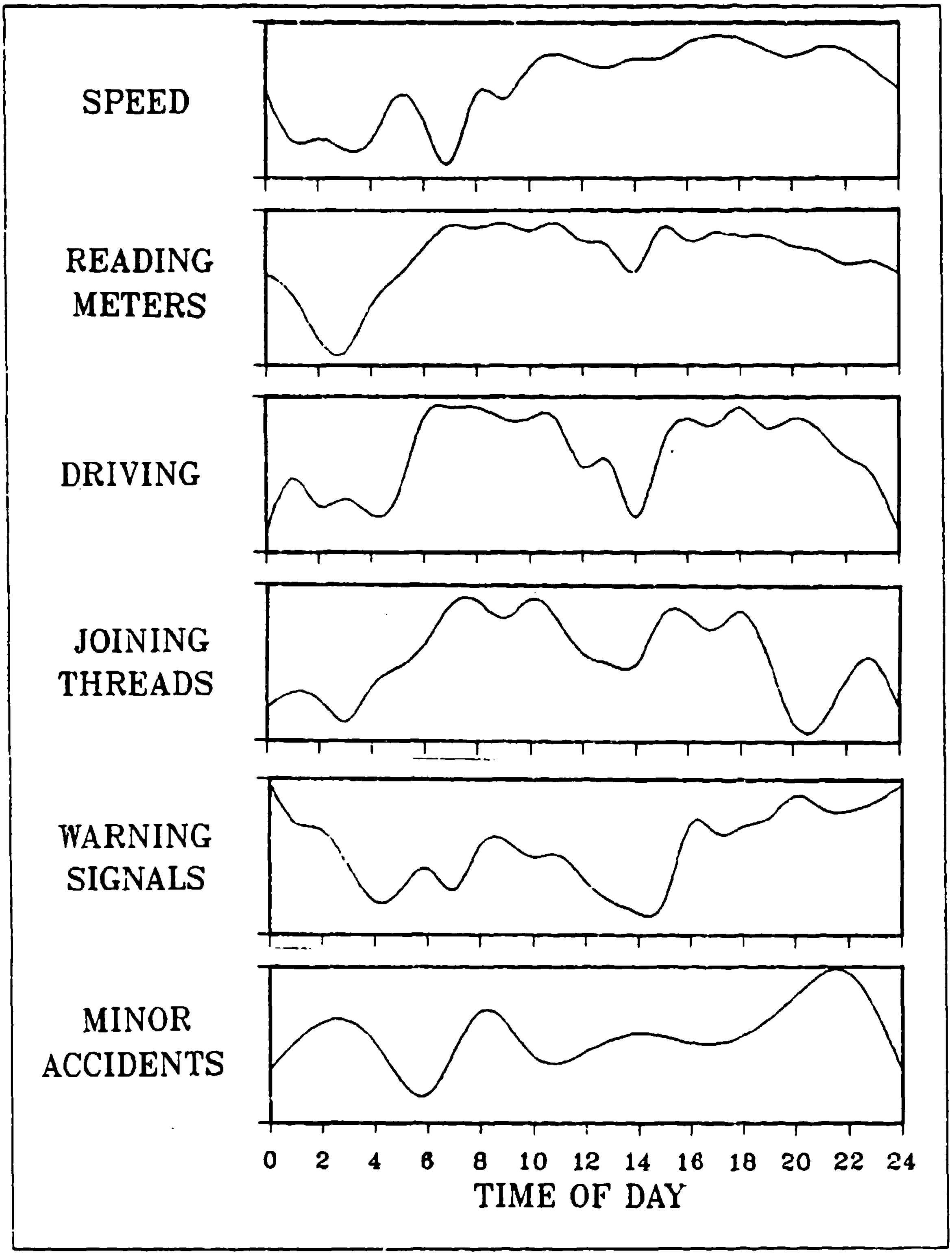


Figure 2.3 24-Hour Performance Curves

circadian rhythms of performance (memory-loaded cognitive, perceptual-motor, or short-term memory tasks) [Ref. 9: pp. 290-291]. Tasks of low memory load demonstrated a high correlation with body temperature, but higher memory load work did not follow this pattern [Ref. 25: p. 21].

Vigilance and simple repetitive tasks appear to parallel the temperature cycles. Such non-memory tasks (of high optimal arousal level) achieve low performance at night when there has been no adaptation of circadian rhythm and improves as the rhythm adapts over successive nights. Conversely, tasks of low optimal arousal level (complex, high memory load) have performance rhythms which are inverses to the temperature cycle [Ref. 3: p. 103].

Rest breaks and pauses have been shown to be beneficial to human performance. The rest break, however, need not always be a period of inactivity, but rather a change in work activity [Ref. 22: p. 175]. To reduce "vigilance decrement" after extended periods of time, job rotation is recommended [Ref. 8: p. 233]. While these ideas condone job rotation within the shift, specific time intervals were not discussed.

Similarly, motivation plays a great part in performance. In agreement with the Arousal Theory, when drive and motivation have overcome boredom and monotony, productivity has increased. Personal and management strategy influences how challenging or how monotonous a job is perceived--thus determining motivation. An easy task requires external motivation, while, if the job is interesting and, complex, there will be fewer motivation problems [Ref. [illegible] pp. 142-144].

2. Performance Measurement

A fundamental problem in studying performance is inaccuracy in the testing and measurement of performance. Besides the requirements for large numbers of trials, task analysis and masking problems present significant barriers to achieving acceptable results [Ref. 2: p. 38].

Performance measurement takes on numerous forms depending upon the nature of the work. Many shiftwork studies utilize a battery of tasks when analyzing performance (vigilance, monitoring, information-throughput, arithmetic calculations, choice reaction time, etc.). While the amount of tasks applied tends to heavily load the subjects (and therefore becomes more realistic by reducing other masking effects--motivation, rest breaks, etc.), it becomes difficult to integrate the data from the distinct tasks [Ref. 6: p. 17]. Watchkeeping or vigilance performance is measured by attentive

tasks: auditory vigilance, warning-light monitoring, and meter monitoring. Memory performance may be measured by arithmetic calculation, and sensory-perceptual functions are frequently measured by target identification [Ref. 22: pp. 199-200].

Regardless of the type of performance under study, several aspects must be considered. Some studies have placed a great emphasis for performance measurement on the opinion's of supervisors--this has proven to be too unreliable [Ref. 2: p. 136]. Also, realizing that most task performance is actually a voluntary activity, the concept of motivation must be considered. How hard are the workers trying? It must usually be assumed that workers are trying to perform at the same level of performance at a given time as at any other time [Ref. 7: p. 62]. Some field studies have been discounted because of the "spare capacity" which exists in workers. While spare capacity has several interpretations, in this discussion it refers to the fact that task demands rarely require 100% of an individual's efforts. The level of task demands dictates the level of worker performance. The greater the level of task demand, the lower the spare capacity. Generally, individuals perform below their maximum capacity, but are able to attain maximum productivity when called on. This may ultimately mask rhythms in their efficiency [Ref. 4: pp. 43-44].

A significant masking factor influencing performance is that of *fatigue*. The term fatigue has been used to define a wide range of characteristics from drowsiness and boredom to mental exhaustion and task overload. Most research has generally avoided the topic of fatigue for this reason. Nevertheless, general fatigue-related factors influence (or mask) the targeted performance measures. Extended work periods tend to magnify the effects of fatigue [Refs. 22,7: pp. 214, 76]. In one study of naval watches, due to lengthy periods of uninterupted work, the anticipated improvement in performance during the day was not found due to fatigue. Also, the expected decline in nighttime performance was noticeably increased [Ref. 8: pp. 232-233].

Motivation is an additional factor influencing productivity. For example, this may become visible as *end-effect* improvement in performance. As a worker approaches the end of his or her work period, the excitement of the end of work, etc. may stimulate higher performance that would be seen under the 'normal conditions. [Refs. 7,6,13: pp. 70, 10, 881].

E. SHIFTWORK EFFECTS

The consequences of shiftwork on human behavior are far reaching. The effects on performance and fatigue have already been discussed. Outside the workplace,

shiftwork has had a great impact on the domestic and social lives of workers. Many workers feel that effects of shiftwork on their social life are more significant than conflicts in sleep, fatigue, etc. [Ref. 9: p. 246]. Although a wide range of work schedules exist, it is unfortunate that society has held fast to its social customs to which complement primarily one routine: the 'standard' eight-hour working day [Ref. 1: p. 35]. The cultural consequences of shiftwork fall into five areas: sleep, social life, domestic life (including eating habits), health, and attitudes.

1. Sleep

Three main effects of shiftwork on sleep are recognized. The first is a change in the duration of the main sleep period. For workers on a night shift, this results in a 1-to-2 hour reduction in the primary sleep period versus day shifts.

Secondly, shiftworkers exhibit a greater amount of sleep per day on the average compared to non-shiftworkers. This is compatible with the previous statement when it is noted that shiftworkers tend to take longer naps apart from the primary sleep time. Increased sleep time on days off/rest days also increases this daily average [Ref. 15: pp. 629-630]. This extra sleep on days off appears to be a pay-off or compensation for the *sleep debt* which has built up during the work days [Refs. 8,16: pp. 352, 1583]. The term sleep debt refers to the fact that workers on a given watch schedule get less than the normally-needed quantity and quality of sleep over a period of time. This lost sleep accumulates and becomes a debt which may later have to be reckoned with [Ref. 2: pp. 53-54]. Specifically, as the number of consecutive night shifts increases, the sleep debt becomes greater [Refs. 2,14: pp. 178, 350].

The last effect is a change in the quality of sleep. Shiftworkers experienced more time awake, increased Stage 1 sleep, reduced REM, and "a disruption of the normal temporal organization of the sleep stages during daytime sleep" [Ref. 15: p. 630]. Some night workers feel that their sleep in the daytime is less refreshing than during the nighttime [Ref. 17: p. 11]. Sleep during the day is found to be more frequently disturbed by ordinary daytime noises: street and traffic noise, children playing, housework, housing conditions, etc. [Refs. 18,4: pp. 179, 80]. A major complaint of shiftworkers (as revealed by numerous surveys) is of sleep disturbance [Ref. 2: p. 190].

Since the 24-hour sleep-wakefulness cycle is in response to established social norms and community activities, deviation from these established circadian rhythms causes the sleep problems which shiftworkers experience [Ref. 12: p. 625].

Sleep effects of shiftwork also depend on the category of shift work involved. For individuals on rapidly-rotating shifts, it is felt that the sleep debt which quickly builds up requires several days off after each duration of night work to recover [Ref. 3: pp. 105-106]. However, researchers attest that recovery from the sleep debt may not depend on the additional sleep gained on days off, but rather a resumption of the normal daily sleep-wakefulness routine [Ref. 19: p. 103]. For rapidly-rotating shifts, up to 75% of the sleep and general activity may be performed on the normal diurnal routine. The other 25% occurs during the night work time of the cycle [Ref. 3: p. 116]. Similarly, 12-hour shifts seem to be more suitable for sleeping than 8-hour schedules, since for three-fourths of the time a normal diurnal sleep pattern can be maintained on the former routine [Ref. 20: p. 490]. Individuals on permanent night shift appear to experience longer sleep duration than rotating shift workers [Ref. 7: p. 185].

Another factor in sleep duration (and quality) is the variation in the start/stop times of the shifts. Those day shifts which begin early (before 0700) are accompanied with shorter sleep duration prior to work [Refs. 14,21: pp. 354, 135]. This can be accounted for by the fact that, while workers are required to go to work several hours earlier than usual, they normally go to sleep at the 'customary' time [Ref. 8: p. 18]. Similarly, late-finishing afternoon and night shifts exhibit reduced sleep length following work [Ref. 14: p. 354]. Additionally, research indicates that day workers sleep immediately before work (rather than after work as for night workers). This will certainly further confuse any possible adjustment of circadian rhythms [Ref. 8: p. 265].

2. **Social**

Generally, the social effects of shiftwork are dependent on the local traditions of shiftwork [Ref. 18: pp. 162-163]. In a social environment comprised of shiftworkers, commonality between schedules and comraderie among the workers support the effects of shiftwork. Shiftworkers will comfortably associate with other shiftworkers [Ref. 4: pp. 96-100]. If this environment does not exist, then shiftworkers will find it difficult to make friends and pursue balanced social relations. The worker's availability becomes unpredictable due to his or her varying and 'unsocial' working hours. Friends and relatives are unable to plan for and to include the shiftworker in recreation and social activities [Ref. 4: pp. 88-96]. Among the more notable activities of which shiftworkers are deprived are TV viewing, sporting events, and active membership in organizations [Refs. 18,2: pp. 163-170, 218-224].

In order to obtain extended periods of time off, shiftworkers will consciously work long hours or tougher schedules [Ref. 26: p. 1], and, to participate in activities with friends and family, these individuals prefer free weekends instead of days off during the week. The arrangement of the free time has a significant effect on the attitudes of the workers [Ref. 34: p. 338].

Conversely, for those individuals who are unable to obtain the free time with friends and family, their activities turn from the more normal group functions toward solitary activities: do-it-yourself projects, gardening, fishing, working a second job, etc. [Refs. 18,17: pp. 170, 22]. While society, as a whole, is too diverse to make concrete generalizations, it is widely accepted that the social advantages of shiftwork are outweighed by the disadvantages [Ref. 2: pp. 211-225].

3. Domestic

The domestic effects of shiftwork depend greatly on the attitudes and influence of the spouse [Refs. 17,27: pp. 19, 18]. The opinions are usually directed at the incidences of night work, since these times are much more different that the 'normal working day.' The effects are divided into advantages and disadvantages:

<u>Advantages</u>

- if both husband and wife work, one will be able to help out at home when the other is at work.
- help with the children and shopping will be provided.
- more leisurely daytime activities together will be possible.

<u>Disadvantages</u>

- interference with housework because the spouse is asleep or in the way.
- spouse lonely in the evening or nervous when alone at night.
- difficult to keep the children quiet during the day (so spouse can sleep).
- difficulty in scheduling preparing meals [Ref. 4: pp. 91-92].
- interference in spouse's routine.
- parental role problems [Ref. 2: pp. 214-218].

Despite the higher incidence of family disturbances, parent-child relationship problems, and sexual difficulties for shiftworkers [Ref. 12: p. 627], no evidence has been found of increased divorce rates [Refs. 18,4: pp. 170, 94]. In fact, shiftwork may be advantageous to those experiencing marital difficulties by reducing the time spent together [Ref. 9: p. 258].

Related to domestic life are the eating habits of shiftworkers. The ingestion of food has already been mentioned as a recognizable circadian rhythm, so it is no surprise that it readily conflicts with varying shiftwork schedules. Generally, shiftworkers "tend toward irregular meals and types of food which are quick to prepare" [Ref. 4: p. 76]. Workers may actually try to maintain their normal eating habits regardless of what schedule they are on. From one study, for a change from day to night work, more than one third of the individuals took four or more days to adjust to the new meal times, while almost two-thirds of the group readjusted immediately back to 'normal' meal times, when they shifted back to day work [Ref. 18: p. 185].

4. **Health**

Research on the relationship between shiftwork and health has been voluminous, but much of the work is subject to two major biases. First, data collection is subjective--much emphasis has been placed on the interpretation of personal health information through opinions and surveys [Ref. 18: pp. 186-189, 195]. Second, results are masked since many workers of poor health have been removed from the shiftwork population (either voluntarily or otherwise.) The resulting individuals may then comprise a heartier, healthier "survivor population" [Refs. 4,9: pp. 69, 280-281]. This would certainly skew any statistical assessment.

One conclusion which is deemed accurate concerns the mortality of shiftworkers. Researchers agree that there appears to be no difference in the death rate of shiftworkers when compared to normal day workers. Similarly, there are no differences in the causes of death [Refs. 2,4: pp. 203, 64-65].

While selected studies have sighted particular health effects of shiftwork [Refs. 28,8,9: pp. 120-122, 363, 281], only one common thread is found among the majority of the research: gastro-intestinal symptoms and diseases [Ref. 3: p. 115]. A higher percentage of shiftworkers (versus day workers) have gastric disorders (upset stomachs, ulcers, etc.) [Refs. 5,18,2: pp. 29, 191-192, 202]. These digestive problems can be traced directly to the sleep and eating habits of shiftworkers. Interestingly, these health difficulties frequently coincided with times of shift change [Refs. 12,2,18: pp. 630-631, 201-202, 186].

5. **Attitudes**

Since the specific shiftwork schedule establishes the living routine for the workers, shiftworkers' attitudes may directly indicate the positive and negative aspects of the existing schedule. For example, shiftwork satisfaction and the distance to

commute to work have an inverse relationship: the greater the distance, the lower the satisfaction [Ref. 17: p. 28].

Interestingly, it has been discovered that, prior to or during a shift schedule change, attitudes of workers reveal dissatisfied comments about the new hours. On the other hand, once the new routine has been established, the overall attitudes improve and workers object to further schedule change [Ref. 18: p. 146].

A study was made of different 12-hour shift schedules in three factories: the first utilized a weekly rotating shift, the second rotated fortnightly, and the third monthly. The majority of workers preferred their own existing cycle regardless of which one it was. This typifies the idea that overall satisfaction increases as the workers become accustomed to the schedule and their environment [Ref. 23: p. 6]. Habit is a significant factor in "choice of rota and of satisfaction with shiftwork" [Ref. 27: p. 18]. Some studies have revealed that since most workers vote for the shift system they are working on, accurate recommendations for optimal shift systems can rarely be obtained from questioning shiftworkers [Ref. 29: p. 9].

Personal choice seems to play a large part in overall acceptance of a shift schedule. By choosing their own shift routine some workers are able to adapt it to their own needs [Ref. 27: p. 20]. When considering the scheduling for air traffic controllers, the Federal Aviation Administration considers the practical input from local controllers to be an integral part of shiftwork system design: "personal preference/freedom of choice means that a worker has more control over his/her life than might otherwise be the case" [Ref. 26: p. 6].

Table 2 reveals one question from a major survey which examined the attitudes of workers [Ref. 30: p. 829]. The highest responses to this question seem to agree with the previously-examined resistance to circadian rhythm adaptation. The maintenance of the normal social Zeitgebers and sleeping routine seriously conflict with shiftworking.

F. COMPARISON OF SHIFTWORK CHARACTERISTICS

Examining the three main categories of shiftwork, the advantages and disadvantages of each are discussed. Other parameters are also be compared.

1. Permanent Shifts

As previously discussed, adaptation to nightwork for a permanent shift system is never complete. The inversion of the normal temperature curve can never seem to be obtained for numerous reasons, but rather results in a flattening of the curve. Some

TABLE 2

EXCERPT FROM SURVEY

"What things do you dislike about shiftwork ?"

Effects on social life	61 %
Irregular sleeping times	47 %
Working at night	44 %
Irregular meal times	38 %
Early rising	35 %
Effects on health	17 %
Other	7 %
No dislikes	9 %

experts maintain that a permanent shift system should be used "where the cost of an error is extremely high" (e.g., nuclear power plant operators, air traffic controllers) and the workers should be "dissuaded from reverting to a day-oriented routing on rest days" [Ref. 8: p. 265]. This is not an acceptable nor reasonable scenario.

It has already been noted that the accumulated sleep deficits of permanent night work causes a drop in performance as time goes on [Ref. 7: p. 187].

Air traffic controllers dislike permanent night shift for several reasons:

- circadian disruption occurs when the change back to day activity and night sleep is made on the weekend.
- loss of proficiency by dealing with the low traffic volume for long periods.
- isolation from the mainstream of facility activities.
- loss of training experience and crew briefings.
- reduced social contact, in and out of work.
- disruption of normal family life [Ref. 26: p. 5].

Conversely, other workers prefer permanent night shifts:

- orderliness of work at night.
- less hurry and scurry.
- less rush and chaos.
- pleasanter atmosphere.
- greater sense of companionship.

- fewer interruptions from clerical, technical, supervisory staff [Ref. 18: p. 152].

2. Slowly-rotating Shifts

Although commonly used, slowly-rotating shifts (typically weekly rotating) may suffer the disadvantages of both permanent and rapidly-rotating systems. They include enough night shifts for a worker's circadian rhythm to begin adapting to the new work time, are not long enough to allow adjustment in the sleep/wakefulness cycle [Ref. 3: p. 106].

> No sooner has the body adapted itself to the new pattern of activity by inverting the temperature cycle than it is forced to revert to a different pattern, and so on from week to week [Ref. 32: pp. 431-432].

3. Rapidly-rotating Shifts

For rapidly-rotating shifts, the idea of forcing adaptation (inversion) of the temperature curve is foregone. Rather, by working such short periods on nights (usually one or two in a row), the physiological rhythms are minimally disturbed [Refs. 18,10: pp. 176, 742]. More night sleep is obtained on working days and days off, and more extended leisure time is available [Ref. 33: p. 251].

One identifiable point is that when slowly-rotating shifts have been replaced by rapidly-rotating shifts, the workers are more satisfied [Ref. 31: p. 579].

The definite trend in existing shift patterns is towards rapidly-rotating shifts, with few nights in succession. The quick return to the normal diurnal rhythms is desirable [Refs. 2,31: pp. 179, 578]. It is viewed as an acceptable compromise between sleep and performance [Ref. 15: p. 639].

G. RECOMMENDATIONS

Researchers have continuously provided numerous recommendations for the design and operation of shift schedules. Based on the information already discussed in this chapter, the following recommendations have been collected:

1. The number of consecutive night shifts should be minimal. Preferably, only single night shifts should be used, but up to two may be allowed. This will prevent any loss of entrainment or adaptation in phase, and avoid the accumulation of sleep debt [Refs. 29,2,21,34: pp. 9-10, 183-184, 135-136, 331].

2. Allow at least 24 hours free time after each night shift. This will allow for the payment of the sleep deficit and will promote the maintenance of the normal circadian rhythms [Refs. 29,34: pp. 9-10, 331].

3. The cycle of the shift system should not be too long. A cycle of less than four weeks allows for greater planning by the shiftworker and his or her family for recreational and leisurely activities. Many workers feel that extremely long cycles (> 60 days) make it tough to plan such activities [Refs. 34,14: pp. 331, 362].

4. Duration of the shift should be a function of the workload. Consideration of both the mental and the physical load of the tasks should be made when assigning the length of the work shift [Refs. 34,14: pp. 331, 358]. The longer the shift, the more subject a worker is to fatigue and other factors [Ref. 6: p. 14].

5. Successive days off should be maximized. This includes two whole days off on weekends to allow the worker adequate time for a normal social and domestic life [Refs. 34,2,21,29: pp. 331, 183-184, 135-136, 9-10].

6. Adequate intervals between two shifts must be given. This is to limit fatigue. It also increases the attractiveness of rapidly-rotating cycles. [Refs. 2,21,35,5: pp. 183-184, 135-136, 245, 28].

7. Early morning starting times (before 0700) should be discouraged The earlier the shift is, the shorter the duration of sleep obtained the previous night is. Also, accident rates and self-rated fatigue is higher when the shifts start earlier [Ref. 14: pp. 352-354].

8. Workers should be educated about circadian rhythms and their effects. This training should include explanations of adaptation. Guidance can be provided to develop an adequate sleep regimen and proper eating habits. Additionally, workers should be encouraged to obtain regular medical examinations to monitor their health and possible ill-effects of shiftwork [Refs. 5,2,26: pp. 27, 208-209, 7].

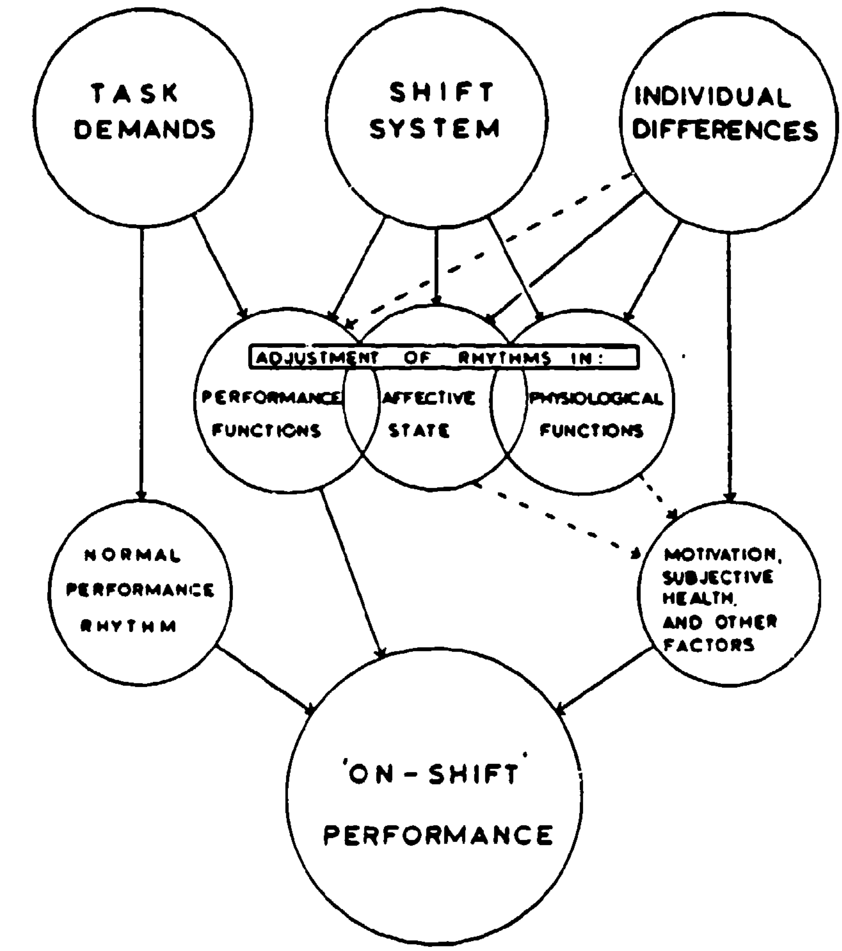
9. Direction of rotation should be forward. Backward rotation results in too short between-shift intervals; besides increasing fatigue, this restricts the allocation of days off. Forward rotation allows more available alternatives to provide days off [Ref. 14: p. 361].

10. Supervisors should examine the workers' jobs. If the tasks are prone to performance fluctuation as a result of sleep loss or adaptation of circadian rhythms, then appropriate action should be considered [Ref. 4: p. 55].

H. A SHIFTWORK MODEL

A descriptive model (Figure 2.4) has been proposed to illustrate the manner in which performance is affected by the various factors discussed in this chapter. While this model does not provide any great solution to the problems encountered in

shiftwork, it does emphasize that performance is the cumulative sum of many different parameters.



[Ref. 2 : pp. 240-241]

Figure 2.4 Shiftwork Model

I. THESIS HYPOTHESES

Utilizing the literature review as supporting evidence, the following hypotheses concerning performance are made in reference to the three research questions.

1. Performance during DAY watches will be higher than performance during NIGHT watches. This is due to the anticipated normal diurnal rhythm cycle which the watchstanders are expected to maintain.

2. Performance will decrease as the time on watch increases. The level of performance at the beginning of the watch (the first four hours) will decrease throughout the watch, reaching a lower level by the end of the watch (the last four hours). This is a result of fatigue due to the extended length of the watch.

3. Performance differences between watches D1, D2, and D3 will not be significant. The constant performance levels during the DAY watches will be due to the normal circadian rhythm of the watchstanders. Performance on the NIGHT watches will decrease as the night watches progress (N1 to N2 to N3). This decline in performance within the NIGHT watches reflects buildup of a sleep debt, and failure of the body to successfully adapt to a inverted (nightly) routine.

III. SAMPLE--COMMUNICATION STATION SAN FRANCISCO

A. GENERAL

1. Operational Mission

Coast Guard Communication Station San Francisco is under the operational control of Commander, Pacific Area (PACAREA) and the administrative and technical control of Commander, Twelfth Coast Guard District. Communications services are provided to all operational commanders and mobile units as well as other government agencies. Among the various functions are:

- to provide a reliable, secure, and rapid means of exercising command, control, communications, and coordination of Coast Guard operations within the Pacific Maritime Area.
- to provide a means by which other forces, including international maritime, aeronautical commerce and the boating public, may communicate with operational commanders whenever necessary.
- to guard specified international distress frequencies and respond to emergency signals on other frequencies.
- to provide voice, radioteletype, and radiotelegraph service between operational commanders ashore and mobile units.
- to insure a high standard of operational and military readiness to readily integrate with the Navy whenever necessary and serve as an adjunct to the Naval Communication System in peacetime.
- to function as the Coast Guard Communications Area Master Station Pacific (COGARD CAMSPAC) for the Pacific Area Communications System [Ref. 36: p. 1-1].

2. Physical Description

The main facility (receiver and operations site) is located within the boundaries of the Point Reyes National Seashore, approximately 51 miles north of San Francisco, California. Family housing and a BEQ (bachelor enlisted quarters) are provided for station personnel at the town of Point Reyes Station, 11 miles from the COMMSTA (approximately 20 minutes driving time).

B. OPERATIONS DEPARTMENT WATCH ORGANIZATION

1. General

The Operations Department of the COMMSTA maintains a continuous communications watch at the main facility. The head of this department, the Operations Officer, is a Chief Warrant Officer (COMMS). Table 3 indicates the enlisted personnel billets of the Operations Department [Ref. 36: p. 2-1]. One of the five senior individuals is assigned the position of RMIC (Radioman-in-Charge). Among the RMIC's duties is the coordination of the station's watchstanding routine.

TABLE 3
OPERATION DEPARTMENT BILLETS

Billet	Number
RMCM	1
RMC	4
RM1	10
RM2	10
RM3	20

The watch schedule and duty section list is prepared by the RMIC with the approval of the Operations Officer. For 11 months COMMSTA San Francisco has been operating in a four-section rotation with the schedule as previously outlined in Figure 1.1. The sections are designated ALPHA, BRAVO, CHARLIE, and DELTA. Watch section assignments are indicated in Figure 3.1.

For this study, the number of consecutive night shifts is fixed at three. Shifts are of 12 hours in length: from 0600 to 1800 and 1800 to 0600, local time. Leisure time is indicated in Figure 1.1 (TIME OFF). Duration of an entire shift cycle is 84 days (nearly three months). Completion of a single rotation, i.e., 3 days/3 nights plus days off, takes 12 days. Historically, the shift system has been regular for nearly an entire year. Lastly, direction of rotation is inapplicable for a 12-hour shift.

2. Duties

Each watch section consists of approximately 10 persons to fill the required positions. Three levels of qualification exist within a watch section: Communications

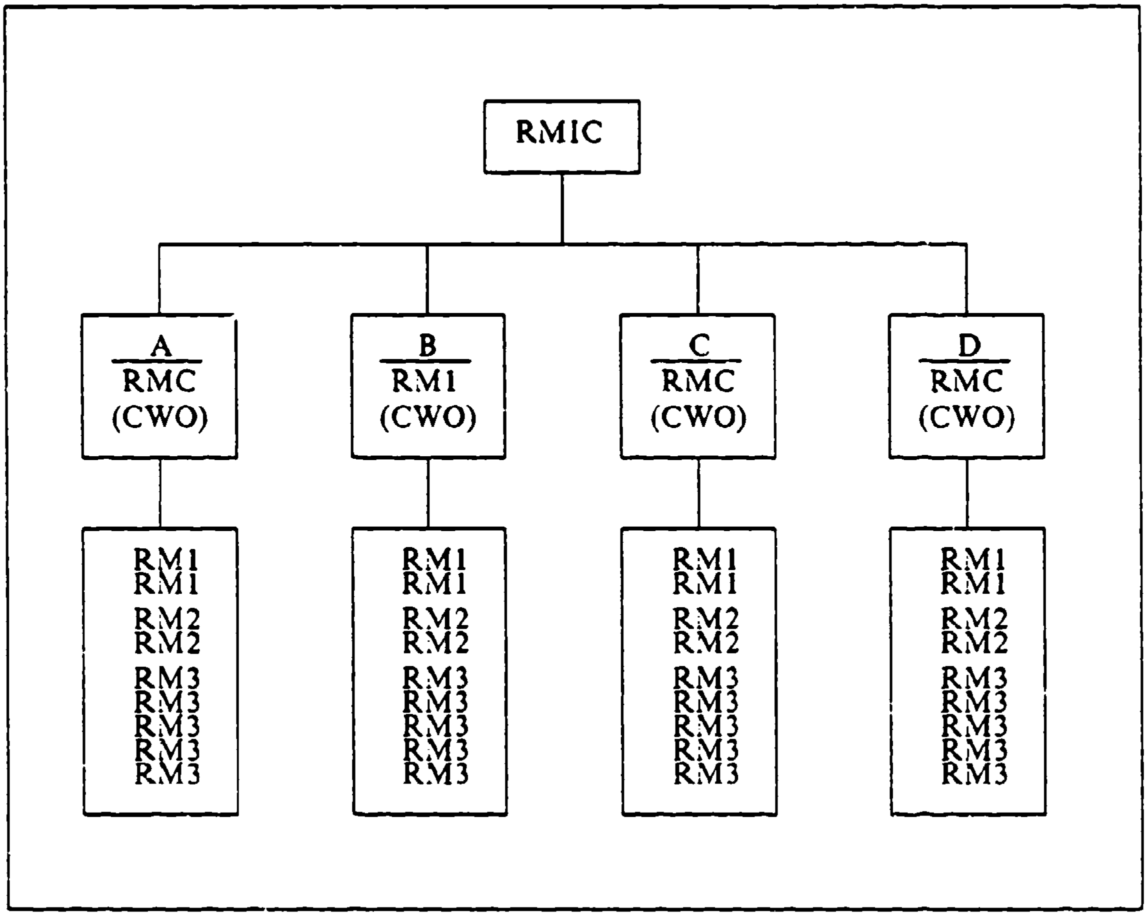


Figure 3.1 Watch Section Organization

Watch Officer (CWO), Technical Control (TECH CONTROL), and operator. Basic qualification is at the operator level. Next is TECH CONTROL, and finally, for the senior personnel, CWO is the highest qualification. In charge of each section, the Communications Watch Officer is responsible for all communications activities at the station.

Among his/her duties is to "ensure that the smooth flow of traffic is maintained including proper and efficient loading and that all broadcasts are made on time, in the proper format and that proper circuit procedures are followed. Additionally, the CWO shall ensure that all personnel assigned to the duty section comply with all Coast Guard and COMMSTA regulations and directives" [Ref. 37: p. 1-2].

The CWO is normally a chief or first class petty officer. If more than one such individual in a duty section is qualified as CWO, normally the senior person will assume the duties as CWO. The second individual will perform the duties of Technical Control for most, if not all, of the watch, and acts as a "supervisor" to the other positions, by assisting the Communications Watch Officer. A major advantage of having two qualified CWO's in any one duty section is that it allows those individuals time for leave and other authorized absences without jeopardizing the effectiveness of the watch.

To support the command's mission, several specific operations are maintained [Ref. 38: pp. 3-4]:

- *MF Distress*--a continuous radio guard of the international morse code CW distress frequency.
- *HF AMVER*--the Automated Mutual-assistance VEssel Rescue program, an international computerized search and rescue program coordinated by the Coast Guard.
- *Secure Ship/Shore Radioteletype (RATT)*--a secure method for the transmission and receipt of operational messages to Coast Guard and Navy units.
- *Non-secure Ship/Shore Radioteletype (RATT)*--a non-secure method for the transmission and receipt of operational messages to Coast Guard, NOAA, Military Sealift Command, and other government vessels.
- *Simplex Teleprinting Over Radio (SITOR)*--radioteletype service to commercial vessels.
- *Broadcast*--the preparation, transmission, and monitoring of weather and Notice-to-Mariners information.
- *Air-Ground*--HF voice communications between the station and Coast Guard or other government aircraft.
- *Technical Control*--a quality control position which includes tape recording operations, equipment configuration, and line level monitoring.
- *Secure Voice*--secure HF voice communications for Coast Guard operational traffic.
- *Landlines*--receipt and transmission of message traffic from Coast Guard units and other government agencies.

These functions are supported by numerous operating positions located inside the communications center (Figure 3.2). Each position consists of an operator's console which is able to access a computer to control the transmitters and transmitting antenna. Several receivers may be physically located within each console, and they can be patched (via the console) to any of a number of receiving antenna. [Ref. 38: pp.

3-4]. The center of focus for this study is the duties of message processing (as defined in Section B of Chapter 4). These tasks are generally non-memory and repetitive in nature.

3. Watchstanding

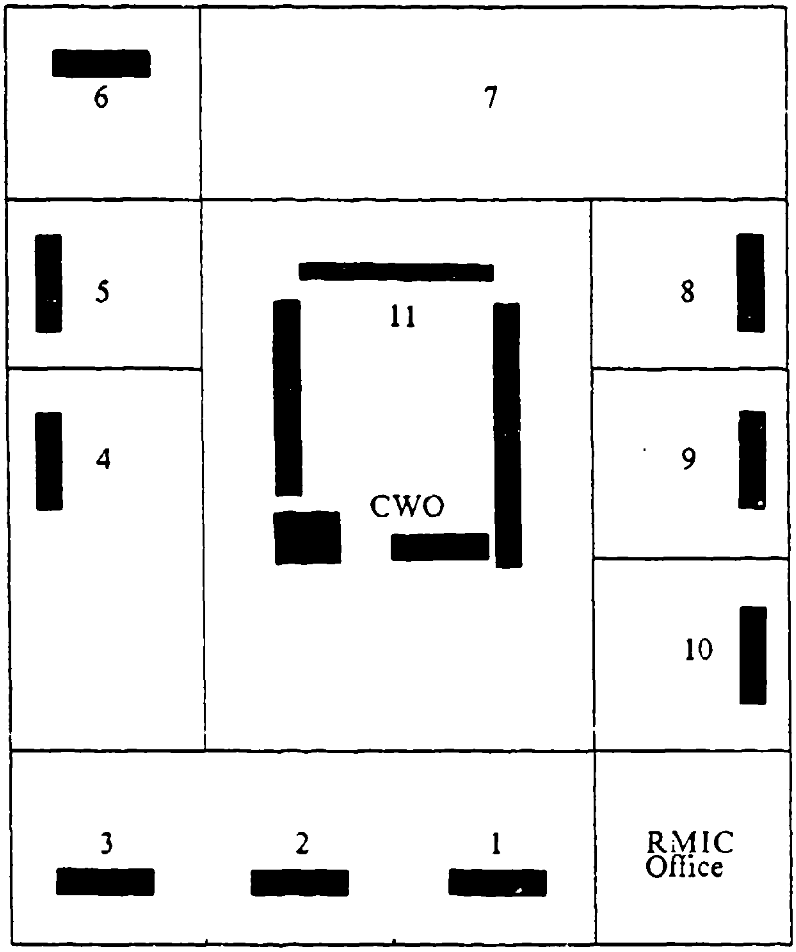
To assist in the commute to and from the COMMSTA, a government van is available to watchstanders for transportation between the housing site and the station. The van usually leaves the housing area 1/2 hour prior to the relief of the watch. Watchstanders are expected to be at the station ready for watch 15 minutes before the hour.

Prior to relief of the watch, the oncoming duty section assembles in a conference room outside of the communications center (COMMCEN). The oncoming CWO enters the COMMCEN and receives a full briefing from the offgoing CWO. This brief includes the current state of activities at the COMMSTA, including equipment status, active operations, and problems. The oncoming CWO then makes a complete briefing to his/her duty section in the conference room. Following this brief, which normally last from five to ten minutes, the oncoming watch performs on-site relief at the individual positions and the watch is formally relieved.

This type of relief process (rather than individual on-site relief) achieves several objectives. First, it organizes the watch section as a team rather than as individuals. Second, it gives everyone the 'big picture'--the status of operations throughout the COMMSTA. (This is invaluable since most, if not all, of the watchstanders will be rotating through several of the positions in the COMMCEN.) Lastly, this organized approach towards relief allows for a concise and smooth transition from one duty section to the next, under the control of the CWOs.

Communications Department Standing Order No. 9 delineates the requirements for watchstanding and relief of watch [Ref. 37: p. 9-3]. Among the standing orders are the following:

- No watchstander shall leave his/her watch unless replaced by a fully-qualified relief.
- Watchstanders shall be rotated among watch positions during the watch period.
- Watchstanders shall not depart their place of duty prior to the end of their watch without receiving prior permission from the CWO.
- All watchstanders shall remain alert and conform to the rules and regulations governing the conduct of communications.



Position	Activity
1	MF (500 Khz)
2	Spare
3	HF AMVER
4	Non-secure Radioteletype
5	Secure Radioteletype
6	Secure Voice
7	Technical Control
8	Unclassified Radioteletype
9	Air/Ground, SITOR
10	Broadcast
11	Landlines

[Not To Scale]

Figure 3.2 Communications Center

- Prior to relieving the watch, the oncoming operator will ensure that the operating position is neat and that all appropriate information has been passed.
- The watchstander being relieved will ensure that the relief is briefed and ready, in all aspects, to take the watch.
- The operator being relieved is responsible for traffic pending at the time of relief to the extent that all pending action is made known to the relieving operator.
- Once relief is offered and accepted, the relieving operator is responsible for the condition of the position. If the condition is unacceptable, relief should not be offered until such time as the condition is made acceptable. Conflicts shall be resolved by the CWOs.

Once the relief is executed, the oncoming duty section is responsible for the operation of the communications center under the guidance of the Communications Watch Officer.

The CWO also coordinates, one, the rotation of the personnel among the the various watch positions, and, two, the temporary relief of individuals for rest breaks, meal times, etc. Position rotation normally occurs at intervals of three hours. No set pattern is established for such rotation. The CWO makes the changes as deemed by the current operations and the qualifications (and desires) of the personnel. If the duty section has fewer personnel than normal, the CWO may extend the interval of rotation to four hours.

A goal of the command is to allow watchstanders to eat their meals outside the COMMCEN in an adjoining galley area. However, continuous personnel shortages prevent this, and the watchstanders must eat at their operating positions while they are performing their jobs. While this provides no actual rest time from their duties, the personnel accept this fact as a tradition of watchstanding at COMMSTAs. 'We've been doing it for so long now, we can keep on doing it', etc.

Actual departure from the Communications Center for the purposes of using the head facilities, galley microwave, soda machine, cigarette break, etc. is accomplished under the direction of the CWO. Many of the positions (CW, AMVER, TECH CONTROL, Air-to-Ground) require a qualified person to be ready at the operating position constantly. Temporary relief is provided (as operations allow) by one of the other 'flexible' operators assuming their duties for a period of several minutes.

Smoking is not allowed at the operating positions on the perimeter of the COMMCEN (see Figure 3.2), but only in the center area ("on the floor"), and this is granted only at the discretion of the CWO. Smoking is allowed in a passageway outside of the communications center.

During slack time, Coast Guaru training courses and other official publications may be read, but magazines and other unofficial books are prohibited [Ref. 37: p. 9-2].

IV. METHODOLOGY

A. INTRODUCTION

The methodology of this study was divided into two parts. The major emphasis was the measurement of watchstander performance; this is contained in Section B of this chapter. The second part was devoted to a survey of the watchstanders to explain or support the findings from the performance data; this latter study is found in Section C.

B. MEASUREMENT OF PERFORMANCE

1. General Approach

Measurement of performance was conducted at U.S. Coast Guard Communication Station San Francisco over a period of 36 days. During this time the four duty sections were standing shifts of 12 hours in duration on the schedule in Figure 1.1. Performance was measured by examining the message files which are the hardcopy results of the watch section's efforts, and by monitoring the number of CIM errors reported by NAVCOMPARS. Changes in performance were then evaluated in regards to the three research questions.

2. Performance Measures

The major variable of interest for this study is the performance of the watchstanders. Due to the varied nature of the positions within the Communications Center, an exact and consistent measure of performance was difficult to identify initially. Two discrete measures of performance were used in this study.

At the start of this study, the author noticed that a Chief Radioman at the station routinely examined the past day's message traffic (in hard copy form). This file was the collection of the messages received, processed, generated, or transmitted by the watchstanders in the execution of their duties. The supervisor examined the messages for compliance with standard message handling procedures (filing, routing, marking, etc.). Mistakes and deviations from the standards were noted, and this information was returned to the particular watch section that handled those messages. The CWO of that watch section disseminated the comments to the watchstanders. This method provided direct feedback to the watchstanders in an effort to show them their areas of weakness, etc.

Although the procedure as established by the chief petty officer was originally designed to aid in watchstander improvement, it provided this author with an excellent method of measuring watchstander performance for the sake of this study. The existing procedure was altered slightly to identify particular types of errors and the time interval in which the errors occurred.

Additionally, an external measurement of performance already existed. The U.S. Navy provides the COMMSTA with timely feedback in the form of CIMs (Communication Improvement Memorandums). These memos are discrepancies recorded by the Navy's computerized message processing system (NAVCOMPARS). While NAVCOMPARS monitors the message traffic for a wide variety of military commands, the system is also designed to provide this information to each command individually. In this case, NAVCOMPARS (thru NAVCOMMSTA STOCKTON) daily notifies COMMSTA San Francisco of the discrepancies and their exact nature. Such errors are usually due to formatting or addressing mistakes. Nevertheless, receipt of CIMs offers an additional measurement of performance.

Both the local examination of message traffic and the receipt of CIMs were used as measures of performance for this study. The next section describes the error categories more specifically, and the last section explains the actual data collection.

3. Error Descriptions

As previously mentioned in Chapter 3, Section B, the watchstanders perform their duties at numerous operating positions within the communication center. Although the command may generate its own message traffic and receive messages as an addressee, much of the work involves the receipt and retransmission of various types of message traffic for other Coast Guard units, federal agencies, and civilian ships, planes, and facilities. The communication station acts as a central node for much of these activities.

For ease of discussion, the term *processing* indicates any of the following: the creation, transmission, receipt, processing, retransmission, routing, or other official handling of message traffic in the support of the missions of the communication station. When a message is processed, a copy of the traffic is kept on file at the COMMSTA for a specified period of time. The action of processing the various messages is guided by Coast Guard and Navy standard operating procedures and requirements.

Following are explanations of the error categories and the factors which were considered when examining the messages for errors. Each of the categories corresponds with one of the columns on the data sheets (see Appendix A).

a. Improperly Stamped

Various individual messages receive ink-stamps denoting their classification. While unclassified messages do not normally get stamped, messages of higher classifications (CONFIDENTIAL, SECRET, and TOP SECRET) are stamped--once at the top, and, again, at the bottom of the message. If such a message comprises several pages, each page is marked accordingly. Additionally, a commonly-used caveat of FOR OFFICIAL USE ONLY (FOUO) may be applied where required. *Improperly Stamped* is defined as:

- the absence of a stamp where required.
- the presence of an inappropriate stamp. (e.g., CONFIDENTIAL where FOUO is required).

b. Non-Delivered Message

This term is associated with the failure of the communications center to 'completely route' a message through the system. Upon receipt of a message it is the center's responsibility to process it as required. If a message does not reach its final destination due to the fault of personnel in the communication center, this is called a *Non-Delivered Message* for the purpose of this study.

c. Message Send Incomplete or Garbled

While transmitting message traffic, operator error or equipment problems may cause the text in the message to become randomly scrambled or garbled and, as a result, partially or fully unintelligible. Normally, when this occurs, the watchstander would notice it and take action to correct the error, including, if necessary, a complete retransmission of the entire message. A similar scenario exists for messages which are sent incomplete, out of sequence, or otherwise not in proper order. If a message somehow manages to get through the system garbled or incomplete, and this error is detected by the RMIC, this is designated to be an error in this category.

d. Missing Service Cross

Manual processing of the message traffic at many of the operator positions requires that a service cross be affixed to the messages. This service cross consists of two lines crossing perpendicularly at the centers. Written in by the processing watchstander, each of the four corners contains one of the following pieces of information:

- the time of receipt or time of delivery of the message (TOR/TOD).
- the means of receipt or transmission (i.e., the circuit the traffic was electronically routed on).
- the destination or source of the message--at the other end of the transmission medium.
- the initials of the operator processing the traffic.

If a message does not contain any of the required elements of the service cross, or is missing the entire symbol, this is termed to be an error in this category.

e. Misfiled Message

After processing, messages are filed in date-time group for specific periods of time, depending on the type of traffic. Frequently, messages have dual-headings due to administrative redistribution or recirculation. Such messages are to be filed under their original DTGs. A *Misfiled Message* is one in which the original is not filed under its date-time group in the message file, is filed in the wrong file, or is filed under a date-time group which is not of the original message. This also includes when a copy is not filed under the re-addressed DTG.

f. CIMs

NAVCOMPARS provides daily Communication Improvement Memorandums (CIMs) to the COMMSTA to indicate errors in message transmission. These errors are usually comprised of PLAD (Plain Language Address Directory) errors, or mistakes in basic message formatting (header, classification, etc.) and other computer-required functions. Receipt of an individual CIM is defined as an error and is assigned to the appropriate time frame in which the message was processed.

g. Other

This category was created to provide for errors which were not identified prior to the beginning of this study. The only additional item, which was recognized by the RMIC as being of interest, was that of message file organization. If the RMIC examined a message file and found it to be sloppy, improperly organized, or generally unprofessional, this was deemed to be an error in this category.

4. Data Collection

Overall data collection was performed by the acting Radioman-in-Charge. The collection was divided into two parts: message file examination and CIM receipt.

For the first part, during each 12-hour watch the Communications Watch Officer collected the traffic processed by the section. The CWO counted up the total

number of messages processed by the watch, and submitted the entire file to the RMIC. The RMIC examined the message file (usually within several days following that particular watch) and checked for any of the errors as discussed in Section B of this chapter. As the RMIC found errors, a check mark was made in the appropriate location on the data collection form (Appendix A). Besides noting the type of error, the interval in which error occurred was also determined (i.e., the first four hours, the second four hours, or the last four hours). For each error that was found, one check mark was recorded on the form. Each individual form corresponded with one particular 12-hour watch.

Next, upon receipt of CIM notification from the NAVCOMPARS at U. S. Naval Communication Station Stockton, the Radioman-in-Charge would make an appropriate check mark in the corresponding time interval. Lastly, once all individual entries were made, row and column totals were calculated and recorded. Additionally, the total number of messages processed was written on the form.

Upon completion, 72 total watches (36 days) were evaluated.

C. SURVEY

1. General Approach

As previously mentioned, the survey was designed to explain or support the findings from the performance data. Performance, itself, is difficult, if not impossible, to measure via subjective questionaires. Therefore, the survey was designed to examine parameters which have an *effect on* performance. Although the survey results alone may yield significant information, the results and conclusions are limited to shiftwork effects on performance.

2. Variables of Interest

Chapter II revealed that performance is dependent upon other measureable factors which may be examined via a survey. Among these are: attitude and satisfaction with shiftwork, DAY vs. NIGHT preference, and fatigue effects.

Higher satisfaction and positive attitudes toward a watch schedule may increase worker performance. The reverse is certainly true for lower satisfaction, etc. These attributes were subjectively investigated by Questions 6 through 13:

- shiftwork dislikes
- health effects of shiftwork
- other effects of shiftwork
- positive/negative aspects of shiftwork
- desire for changes in the watch schedule

Similarly, a preference for DAY or NIGHT watches may indicate a trend for higher performance during the preferred watch. Question 14 examined this. Related to this preference are the diurnal schedules maintained by the workers. If the watchstanders maintain a normal day routine during time-off, they would ideally be more adaptive to a normal work routine, and demonstrate higher performance during the DAY watches. Similarly, if a night routine is maintained during the 72- and 96-hour breaks, this may indicate a tendency to invert (or flatten) the circadian rhythm, hence performance should be higher at NIGHT. Questions 15 and 16 focused on this phenomenon.

Lastly, the length of the watch creates a scenario wherein fatigue might become an important factor. This masking factor would be expected to be more prevalent toward the end of the watches. Question 17 attempted to discern worker perceptions of fatigue over the three periods of the 12-hour watch. Additionally, two questions (18 and 19) are included to provide guidance to the supervisors for battling the effects of fatigue.

It was noted in Chapter II that personal opinion, as revealed in questionaires, may be subject to factors which would decrease the validity of the survey responses. Results become even more inconclusive where the subjective areas of satisfaction and fatigue are considered.

3. Design

a. Construction

When the questions for the survey were designed, an examination was made of past survey studies [Refs. 19,27,30,39,40,41]. Several questions were selected from these sources for use in the survey in this study. (Question numbers refer to the survey in Appendix C.)

- Question 6 [Ref. 30, p. 829]
- Question 7 [Ref. 19, p. 92]
- Question 8 [Ref. 19, p. 94]
- Question 18 [Ref. 39, p. 81]

b. Format

The front cover sheet of the survey was designed to delineate several points:

- an explanation of the purpose of the survey.
- that the survey was not intended to initiate any change in the watch schedule.

- that the survey would not to be used to evaluate individual or group performance.
- that feedback of the study will be provided.
- the ensurance of privacy and anonymity.
- a point of contact for further questions.

The second page gave specific instructions for completion of the survey. The remaining pages were the questions themselves. Questions were of two types: the first five obtained demographic information; the remainder focused on the variables of interest.

c. Testing

Prior to actual distribution, the survey was tested twice. First, the survey was administered to two postgraduate students. They were instructed to look for spelling errors, inappropriate or confusing language, and general flow of the survey. Appropriate improvements and changes were made to the survey based on the comments by these two individuals.

A second trial was made at a local naval communication facility. The survey (with the corrections from the first test) was administered to six radiowatchstanders. While these individuals were currently standing 8-hour watches, they were familiar with 12-hour watches and could properly answer the questions from the standpoint of a Radioman. As a result of the second test, only minor changes were made to several questions.

Once the "master" survey was completed, two alternate forms were created. These consisted of the same questions, but Questions 6 through 19 were rearranged to reduce any effect on the results by the order of the questions. Table 4 indicates the order of the questions for the three iterations. Form 1 is the master survey, and can be found in Appendix C.

4. Data Collection

a. Sample

The original sample of the population surveyed was to consist of those individuals at Coast Guard communication stations who were standing the watch schedule in Figure 1.1. Initially, three stations were operating under this schedule. But, prior to the completion of the study, it was discovered that two of the stations did not operate on this watch schedule. One COMMSTA had altered its schedule prior to the distribution of the surveys and was, therefore, not included in the sample. Next,

TABLE 4

ORDER OF QUESTIONS

Form 1	Form 2	Form 3
6	11	13
7	13	15
8	14	16
9	8	12
10	7	11
11	15	9
12	16	10
13	12	6
14	6	14
15	10	7
16	9	8
17	19	18
18	17	19
19	18	17

only after distribution of the surveys was it learned that a second COMMSTA operated on a schedule which was slightly different than Figure 1.1. COMMSTA Portsmouth operated 3-days-on, 96-hours-off, 3-nights-on, 72-hours-off. This is a reversal of the *time-off* periods from COMMSTA San Francisco. Therefore, the only legitimate sample for analysis with the performance data is COMMSTA San Francisco.

b. Administration

The three forms of the survey were equally distributed to each of the two COMMSTAs. The surveys were mailed together in a single box to each of the stations: 50 to San Francisco, 45 to Portsmouth. As previously mentioned, each individual survey was packaged in a manila envelope to ensure privacy. Upon receipt of the package, the surveys were locally administered by the watch supervisors under the coordination of the RMICs.

c. Receipt

Upon receipt of the completed surveys, several steps were taken prior to examination of the actual answers. First, all of the surveys were removed from the sealed envelopes, and the envelopes were discarded. The surveys were then separated into three groups, according to which *form* they were. Table 5 indicates how many surveys were distributed and returned by form type and total. The surveys were

numbered sequentially to provide organization during the data processing and to ease location for re-examination purposes.

Two of the surveys were completed by dayworkers. Since these individuals were not designed to be included in the sample, their surveys were discarded and not included in the remainder of the analysis.

TABLE 5
DISTRIBUTION AND RETURN OF SURVEYS

		Form Type			Total
		1	2	3	
San Fran	Sent	17	17	16	50
	Returned	14	12	14	40
Portsmouth	Sent	15	15	15	45
	Returned	12	14	12	38
Total	Sent	32	32	31	95
	Returned	44	46	43	133

Each survey was then examined to categorize the answers to those questions which did not provide choice answers or offered *"other ________ (please write in)"* as a response. These 'newly-created' answers were added to the existing answers, thereby ensuring answer categories for all of the responses to the survey.

Following this, the answers from each survey were tabularized to allow analysis via SPSS-X, a computer statistical analysis routine [Ref. 45].

V. PERFORMANCE RESULTS

A. DATA DESCRIPTION

To preserve the anonymity among the four specific watchsections (A, B, C, and D) this study has randomly rearranged the letters A through D. Therefore, while the column "Watch Section" in Appendix B indicates 'A', 'B', 'C', or 'D', these do not correspond with those specific watch sections at COMMSTA San Francisco.

1. Normalization

Examination of the raw data revealed that message load (Total Number of Messages Processed) varied from 48 to 177, with a mean of 99. Transforming (or normalizing) the data was necessary to allow comparison between watches of different message load [Ref. 42: p. 380]. Therefore, the data received from COMMSTA San Francisco was reconfigured to indicate percent error rate vice absolute error occurrence. To perform this, the right-hand column totals from each data sheet were divided by the number of messages processed during that watch (or during that interval of the watch) and then multiplied by 100. This yielded the percentage of messages in error as a percent of the number of messages processed during that time interval. An example calculation is made in Table 6. NOTE: an assumption is made that the distribution of the message load is *uniform* throughout the watch. For example, if 120 messages were processed during a 12-hour watch, then it is assumed that 40 messages were processed during the first four hours, 40 messages during the second four hours, etc. This assumption is necessary because there was no legitimate way to accurately count the number of messages in any four-hour segment of the watch. This adjusted data is tabularized in Appendix B.

2. Sample Size

Since the data was accumulated over a period of 36 consecutive days, the distribution of watches among the four sections is uniform. The breakdown of the sample size is shown in Table 7.

TABLE 6

DATA CALCULATIONS

Time	Total # of Errors	
1800-2200	1	$\frac{1}{39.33} \times 100\% = 2.54\%$
2200-0200	3	$\frac{3}{39.33} \times 100\% = 7.62\%$
0200-0600	2	$\frac{2}{39.33} \times 100\% = 5.08\%$
Total	6	$\frac{6}{118} \times 100\% = 5.08\%$

Total Number of Messages = 118 $\quad \frac{118}{3} = 39.33$

(This example is taken from Day 03--Night in Appendix B.)

B. ANALYSIS DESCRIPTION

1. Error Rate and Performance

Since each watch section is peculiar in its quantity and quality of people, it is difficult to compare the performance between watch sections. Watch sections may be dissimilar due to new personnel-in-training, personnel absent due to leave, training, sickness, etc., experience of watchstanders, and other factors. It is generally assumed that this dissimilarity is random among the section, but, to avoid the introduction of these unquantified variables, comparison between *between* watch sections is minimized. Rather, the increases and decreases in performance *within* particular watch sections or for the four watch sections combined is discussed. Naturally, it was hoped that the four sections each showed performance level increases or decreases in conformance

TABLE 7

SAMPLE SIZE

	# of Watches		
	Day	Night	Total
All Sections	36	36	72
A	9	9	18
B	9	9	18
C	9	9	18
D	9	9	18

For Days:	# of Watches			
	D1	D2	D3	Total
All Sections	12	12	12	36
A	3	3	3	9
B	3	3	3	9
C	3	3	3	9
D	3	3	3	9

For Nights:	# of Watches			
	N1	N2	N3	Total
All Sections	12	12	12	36
A	3	3	3	9
B	3	3	3	9
C	3	3	3	9
D	3	3	3	9

with the overall average. Thereby, specific conclusions would be more appropriate and acceptable if the entire sample and each watch section demonstrated the same pattern in performance level variation.

As discussed in the first section of this chapter, the performance data has been figured to represent the percentage of messages in error out of the number of messages processed during that time interval. Throughout the remainder of this thesis, the terms 'rate' and 'percentage' will be synonymous. A high rate of errors corresponds to a high percentage of errors, and a low error rate corresponds to a low percentage of errors.

The level of performance is opposite to the error rate. A low error rate equates to high performance, while a high error rate is equivalent to low performance. More specifically, since high performance is desired, increases in performance (and decreases in percentage of errors) reflect an improvement in performance. Similarly, decreases in performance level (and increases in percentage of errors) are equal to a decline in performance.

An arbitrary value of 10% for the error rate is chosen to determine whether performance is increasing, decreasing, or steady. Increased performance is defined as a decrease in the rate of errors of greater than 10% during a time interval. Likewise, decreased performance is an increase in the error rate of greater than 10%. Constant performance is indicated by a steady rate of errors (smaller than ± 10%).

2. Statistical Evaluation Method

Statistical analysis of the performance data is limited by two factors: one, the population's standard deviation σ is unknown; two, the sample size **n** is relatively small. If the sample is assumed to be taken from a normal population, then the *t-statistic* provides for proper analysis [Ref. 43: pp. 178-180].

The t-statistic is defined as:

$$t = \frac{x - \mu}{s / \sqrt{n}}$$

where:
- x = mean of the sample
- μ = mean of the population
- s = standard deviation of sample
- n = sample size

In each analysis, the null and alternate hypotheses were established. The null hypotheses focus on $\mu = |10|$ since that value is the cut-off for increases/decreases in performance. **x** and **s** were calculated via MINITAB, a computer-based statistical package [Ref. 44]. Setting $\mu = 10$ (as discussed in Section B), **t** was calculated. This value of **t** was then compared to a value of **t** established for a given confidence interval

and the number of degrees of freedom, $v = n-1$. For this study, the one-sided confidence interval is established at .95 ($\alpha = .05$). Depending on the hypotheses, and the comparison between the two t values, one hypothesis is accepted and the other rejected.

C. ANALYSIS

This section examines the performance of the watchstanders with regard to the three research questions. Is watchstander performance dependent on:

- time of the day (DAY vs. NIGHT) ?
- location within the watch (First 4 hrs vs. Second 4 hrs vs. Third 4 hrs) ?
- location within the watch cycle (D1 vs. D2 vs. D3; N1 vs. N2 vs. N3) ?

1. DAY versus NIGHT

The first examination consisted of comparing the error rates between DAY and NIGHT watches (Table 8). Overall, the error rate was 16% lower at night than during the day (DAY = 4.4, NIGHT = 3.7). In other words, average performance was higher during NIGHT watches than DAY watches. Two watch sections exhibited performance increases (B=47%, C=27%), while one section showed a decrease of 86% (2.2 to 4.1). The fourth section showed steady performance (+3%) between days and nights.

The changes in performance (+3%, +47%, +27%, -86%) were tested to determine if the overall increase in performance was significant.

H_0 : $\mu \leq 10$ (performance at NIGHT is not significantly higher than during the DAY)

$\overline{H}_0$: $\mu > 10$ (performance at NIGHT is significantly higher than during the DAY)

Sample: +3, +47, +27, -86 (% changes in performance by section)

For: $n = 4, v = 3, x = -1.4, s = 45.0$

$t = -0.51$

Using: $t_{95} = 2.132$

$-0.51 < 2.132 \quad \therefore$ reject $\overline{H}_0$, accept H_0

At $\alpha = .05$, the test results indicate that performance at NIGHT is not significantly higher than during the DAY. Despite this, the fact that two individual

TABLE 8

TIME LOCATION

	% Errors	
	Day	Night
All Sections	4.4	3.7
A	3.2	3.1
B	6.0	3.2
C	6.2	4.5
D	2.2	4.1

sections did show significantly higher performance during NIGHT watch than DAY watch is of interest and will be discussed later.

To more closely scrutinize this data, the DAY and NIGHT watches were further divided by four-hour segments within the twelve hour watch (Table 9). During the first four hours all sections showed lower performance during the night than day--overall, 133% lower. This result was tested to find its significance.

H_o : $\mu \geq -10$ (performance in the FIRST four-hour period at NIGHT is not significantly lower than the FIRST four-hour period during the DAY)

$\bar{H}_o$: $\mu < -10$ (performance in the FIRST four-hour period at NIGHT is significantly lower than the FIRST four-hour period during the DAY)

Sample: -175, -58, -140, -390

For: $n = 4, \nu = 3, x = -190.75, s = 141.6$

$t = -2.553$

Using: $t_{95} = -2.132$

$-2.553 < -2.132 \quad \therefore$ reject H_o, accept $\bar{H}_o$

TABLE 9

TIME & LOCATION WITHIN WATCH

First Four Hrs	% Errors	
	DAY	NIGHT
All Sections	1.7	4.6
A	1.2	3.3
B	1.9	3.0
C	3.0	7.2
D	1.0	4.9

Second Four Hrs	% Errors	
	DAY	NIGHT
All Sections	4.7	3.3
A	3.4	3.3
B	5.7	5.2
C	7.5	2.0
D	1.9	2.9

Third Four Hrs	% Errors	
	DAY	NIGHT
All Sections	6.7	3.1
A	4.9	2.7
B	10.3	1.2
C	8.0	4.3
D	3.7	4.4

At $\alpha = .05$, the test results indicate that performance in the FIRST four-hour period at NIGHT is significantly lower than the FIRST four-hour period during the DAY.

Within the second four-hour interval, overall performance improved 30%. But only one section (C) showed improvement (140%) while two sections remained steady. The fourth section (D) declined in performance (-53%). These divided results did not warrant a statistical test.

In the last four-hour period, three of the sections demonstrated improved performance at night than during the day (+45%, +83%, +46%). The last section indicated lower performance at night (-19%). This overall increase in performance from DAY to NIGHT was tested.

H_o : $\mu \leq 10$ (performance in the THIRD four-hour period is not significantly higher at NIGHT than during the DAY)

$\overline{H}_o$: $\mu > 10$ (performance in the THIRD four-hour period is significantly higher at NIGHT than during the DAY)

Sample: +45, +83, +46, -19

For: $n = 4, v = 3, x = 38.7, s = 42.4$

$t = 1.35$

Using: $t_{95} = 2.132$

$1.35 < 2.132 \quad \therefore$ reject $\overline{H}_o$, accept H_o

At $\alpha = .05$, watchstander performance in the THIRD four-hour period is not significantly higher during NIGHT watches than during DAY watches.

a. Message Load

A definite factor in performance is the amount of messages processed during a watch. The *number of messages processed* in a watch is an indication of the work load on the watch section during that time interval. Table 10 indicates the breakdown of the number of messages processed. On the average, DAY watches processed more messages (112) than NIGHT watches (86). This equates to 23% more messages processed during'days than nights. Within watch sections, the percentages are reasonably similar (A=27%, B=12%, C=32%, D=20%). This fact must be taken into account when comparing the performance between DAY and NIGHT watches.

TABLE 10
MESSAGES PROCESSED

	# of Messages Processed		
	Day	Night	Total
All Sections	112.2	85.9	99.1
A	114.6	83.4	99.0
B	94.3	82.7	88.5
C	118.4	80.6	99.5
D	121.7	96.8	109.2

2. Location within Watch

The data was then examined for performance changes within the watch by dividing the watch into three four-hour sections. Error rates for location-within-watch are indicated in Table 11. Overall, performance decreased 25% between the first and second four-hour periods, and decreased 22% between the second and third periods. Two watch sections exhibited performance decreases between the first and second periods (A = 55%, B = 120%), while a third section increased (D = 20%). The fourth section remained steady. These differences between the first and second periods did not warrant testing.

However, three of the sections showed decreased performance between the second and third periods (A = -12%, C = -30%, D = -71%), while one section remained contant during this interval (B = -4%). Since the performance variations between the second and third part of the watch appeared to be similar, this fact was tested.

H_o : $\mu \geq -10$ (performance does not decline significantly between the SECOND and THIRD four-hour periods)

$\overline{H_o}$: $\mu < -10$ (performance declines significantly between the SECOND and THIRD four-hour periods)

Sample: -12, -4, -30, -71

For: $n = 4, \nu = 3, x = -29.2, s = 29.9$

$t = -1.28$

Using: $t_{95} = 2.132$

$-1.28 > -2.132 \quad \therefore$ reject $\overline{H}_o$, accept H_o

At $\alpha = .05$, performance doesn't significantly decline between the SECOND and THIRD four-hour periods.

TABLE 11

LOCATION WITHIN WATCH

	% Errors		
	First	Second	Third
All Sections	3.2	4.0	4.9
A	2.2	3.4	3.8
B	2.5	5.5	5.7
C	5.1	4.7	6.1
D	3.0	2.4	4.1

'First' = first four hours of watch
'Second' = middle four hours of watch
'Third' = last four hours of watch

For closer examination of the performance within watches, the data was divided into DAYS and NIGHTS (Table 12). This is the same data contained in Table 8 but re-formatted.

For DAY watches, all entries showed decreases in performance between the first and second four-hour periods. Overall, the error rate increased 212%. Similarly, for all but one section (which remained steady), performance continued to decrease between the second and third periods (46% more errors). This indicates an overall

TABLE 12

LOCATION WITHIN WATCH & TIME

For Days:	% Errors		
	First	Second	Third
All Sections	1.7	4.6	6.7
A	1.1	3.4	4.9
B	1.9	5.7	10.3
C	3.0	7.5	8.0
D	1.0	1.9	3.7

For Nights:	% Errors		
	First	Second	Third
All Sections	4.6	3.3	3.1
A	3.3	3.3	2.7
B	3.0	5.2	1.2
C	7.2	2.0	4.3
D	4.9	2.9	4.4

decline in performance during the day as the watches progressed. This pattern was tested in two parts.

The first examined the performance change between the FIRST and the SECOND periods.

H_0 : $\mu \geq -10$ (performance does not decline significantly between the FIRST and SECOND four-hour periods during DAY watches)

$\overline{H}_0$: $\mu < -10$ (performance declines significantly between the FIRST and SECOND four-hour periods during DAY watches)

Sample: -209, -200, -150, -190

For: $n = 4, \nu = 3, \bar{x} = -187.2, s = 26.0$

$t = -13.6$

Using: $t_{95} = 2.132$

$-13.6 < -2.132 \quad \therefore$ reject H_o, accept $\overline{H}_o$

At $\alpha = .05$, performance declines significantly from the FIRST to the SECOND four-hour period within a DAY watch.

Next, the performance differences between the SECOND and THIRD periods were checked.

H_o : $\mu \geq -10$ (performance does not decline significantly between the SECOND and THIRD four-hour periods during DAY watches)

$\overline{H}_o$: $\mu < -10$ (performance declines significantly between the SECOND and THIRD four-hour periods during DAY watches)

Sample: -44, -81, -7, -95

For: $n = 4, \nu = 3, \bar{x} = -56.7, s = 39.5$

$t = -2.365$

Using: $t_{95} = 2.132$

$-2.365 < -2.132 \quad \therefore$ reject H_o, accept $\overline{H}_o$

At $\alpha = .05$, performance declines significantly from the SECOND to the THIRD four-hour period within a DAY watch.

NIGHT watch performance does not reveal a similar pattern. Overall performance increased from the first to the second period by 28% and remained steady between the second and the third. None of the watch sections paralleled this. The performance of two sections increased between the first and second periods (C=72%, D=41%) but decreased between the second and third (C=115%, D=52%). One section (B) exhibited the opposite--decreasing 73% between the first two periods and increasing 77% between the second and third. Section A remained steady between the first and second and increased in performance (by 18%) between the second and third periods. Due to the varied nature of these increases and decreases, and the lack of any significant pattern, no tests were conducted on this NIGHT data.

3. Cycle Location

Lastly, the data was examined for patterns by cycle location (D1 thru N3). This data was separated into DAY and NIGHT watches (Table 13).

TABLE 13
CYCLE LOCATION

	% Errors		
	D1	D2	D3
All Sections	3.9	4.1	5.2
A	2.5	1.5	5.4
B	4.6	4.9	8.3
C	6.2	7.2	5.2
D	2.2	4.3	2.9

	% Errors		
	N1	N2	N3
All Sections	4.0	4.1	3.0
A	2.7	5.3	1.3
B	2.2	4.3	2.9
C	3.9	3.8	5.6
D	7.2	2.9	2.1

For the series of DAY watches, overall performance was steady from D1 to D2 and decreased 27% from D2 to D3. This was paralled by only one watch section which had a 69% decrease from D2 to D3. Two sections exhibited a decrease in performance from D1 to D2 (C = 16%, D = 95%), followed by an increase from D2 to

D3 (C = 28%, D = 33%). The fourth section showed an increase (40%) from D1 to D2, then a decrease (260%) from D2 to D3.

For the series of NIGHT watches, overall performance was constant from N1 to N2, and increased 27% from N2 to N3. None of the watch sections exhibited this average performance. While one section (C) was steady from N1 to N2, it showed a 47% decrease in performance from N2 to N3. Two sections indicated performance decreases from N1 to N2 (A = 96%, B = 95%), and increases from N2 to N3 (A = 75%, B = 33%). The last section (D) showed increases in performance over the three watches (N1 to N2 = 60%, N2 to N3 = 28%).

None of the results from either the DAY or NIGHT cycles appeared to have any significance, and no statistical tests were conducted.

To further study the effect of cycle location on performance, the data was further divided by the location within the watch (Tables 14 through 17). Examination of these tables did not reveal any significant patterns of improving or declining performance. As a result, no statistical tests were performed.

TABLE 14

CYCLE LOCATION & LOCATION WITHIN WATCH--DAYS

<u>D1</u>	% Errors		
	First	Second	Third
All Sections	2.0	4.9	4.7
A	1.6	1.1	4.9
B	2.0	6.0	6.0
C	2.3	9.8	6.4
D	2.3	2.8	1.4

<u>D2</u>	% Errors		
	First	Second	Third
All Sections	1.8	5.4	5.0
A	1.9	1.6	0.9
B	0.9	8.8	4.9
C	3.8	7.9	9.7
D	0.7	3.0	4.3

<u>D3</u>	% Errors		
	First	Second	Third
All Sections	1.5	3.7	10.5
A	0.0	7.6	8.7
B	2.9	2.3	19.9
C	3.0	4.9	7.9
D	0.0	0.0	5.6

TABLE 15

CYCLE LOCATION & LOCATION WITHIN WATCH--NIGHTS

<u>N1</u>	% Errors		
	First	Second	Third
All Sections	5.7	3.2	3.2
A	1.0	4.6	2.5
B	4.7	1.0	1.0
C	9.0	0.0	2.8
D	8.1	7.0	6.4

<u>N2</u>	% Errors		
	First	Second	Third
All Sections	5.1	3.7	3.5
A	7.9	3.9	4.1
B	2.3	9.7	0.9
C	5.2	1.1	5.2
D	5.0	0.0	3.7

<u>N3</u>	% Errors		
	First	Second	Third
All Sections	3.0	3.2	2.8
A	1.0	1.4	1.4
B	2.1	5.0	1.7
C	7.2	4.7	4.9
D	1.6	1.6	3.1

TABLE 16
LOCATION WITHIN WATCH & CYCLE LOCATION--DAYS

First Four Hrs	% Errors		
	D1	D2	D3
All Sections	2.0	1.8	1.5
A	1.6	1.9	0.0
B	2.0	0.9	2.9
C	2.3	3.8	3.0
D	2.3	0.7	0.0

Second Four Hrs	% Errors		
	D1	D2	D3
All Sections	4.9	5.4	3.7
A	1.1	1.6	7.6
B	6.0	8.8	2.3
C	9.8	7.9	4.9
D	2.8	3.0	0.0

Third Four Hrs	% Errors		
	D1	D2	D3
All Sections	4.7	5.0	10.5
A	4.9	0.9	8.7
B	6.0	4.9	19.9
C	6.5	9.7	7.9
D	1.4	4.3	5.6

TABLE 17

LOCATION WITHIN WATCH & CYCLE LOCATION--NIGHTS

First Four Hrs	% Errors		
	N1	N2	N3
All Sections	5.7	5.1	3.0
A	1.0	7.9	1.0
B	4.7	2.3	2.1
C	9.0	5.2	7.2
D	8.1	7.9	1.0

Second Four Hrs	% Errors		
	N1	N2	N3
All Sections	3.2	3.7	3.2
A	4.6	3.9	1.4
B	1.0	9.7	5.0
C	0.0	1.1	4.7
D	7.0	0.0	1.6

Third Four Hrs	% Errors		
	N1	N2	N3
All Sections	3.2	3.5	2.8
A	2.5	4.1	1.4
B	1.0	0.9	1.7
C	2.8	5.2	4.9
D	6.4	3.7	3.1

D. SUMMARY

Summarizing the results from this chapter, non-parametric testing revealed significant results for the following hypotheses:

- performance was not higher during NIGHT watches than during DAY watches.
- performance was lower during NIGHT watches than during DAY watches for the FIRST four-hour segment of the watch.
- performance was not higher during NIGHT watches than during DAY watches for the THIRD four-hour segment of the watch.
- performance was not lower in the THIRD four-hour period than in the SECOND four-hour period of the watch.
- performance was lower in the SECOND four-hour period than in the FIRST four-hour period for DAY watches.
- performance was lower in the THIRD four-hour period than in the SECOND four-hour period for DAY watches.

While not statistically significant for all of the sections, performance changes were interesting between DAY and NIGHT watches. Specifically, two watch sections exhibited higher performance during NIGHT watches than during DAY watches. Additionally, the message load (work load) was higher during the DAY watches than during the NIGHT watches.

Further discussion of the results is conducted in Chapter VII.

VI. SURVEY RESULTS

A. PRESENTATION

The results of the survey are listed in order of appearance on the questionaire. In some of the questions, the answers have been re-ordered into descending percentages of responses to ease the analysis. 'NR' indicates that no response was given to that particular question. The percentage calculations do not include the 'NR' entries. An asterisk (*) next to a response indicates that the answer was a 'write-in'.

In the cases where a question asked for the *highest* and the *second highest* choices, both choices are considered equivalent and are combined together into one table. This action pertains to Questions 6, 14, and 19.

For those open-ended questions which solicited the effects and aspects of an activity, any answers which were submitted were itemized and each was considered to be an individual answer. This pertains to Questions 7, 8, 9, 10, and 12. For example, if an individual indicated four negative aspects of the watch schedule (Question 10), then each of these four responses would be considered separate answers.

The term "mid" or "midwatch" is commonly used by radiowatchstanders to indicate the NIGHT watch (1800-0600). Several of the answers use these terms.

The following information, from each survey, is not included in this appendix:

- Months at COMMSTA
- Date of Survey Completion
- Time (local) of Survey Completion
- Watch Section

B. RESULTS

The results of the survey at COMMSTA San Francisco are contained in Appendix D. Analysis of the survey is contained in Chapter VII in the context of further discussion of the performance results.

Since the results from Portsmouth would not reflect the watch schedule under consideration, these surveys were only examined briefly for similarities and differences with the results from COMMSTA San Francisco. Portsmouth's survey results can be found in Appendix E.

VII. DISCUSSION

A. DAY VS. NIGHT PERFORMANCE

The levels of performance between DAY and NIGHT watches deserves attention. Although the data was not statistically significant for the overall sample, two of the four watch sections demonstrated significantly higher performance on NIGHT versus DAY watches. A third section had slightly higher performance during NIGHT than during DAY watches. This result conflicts with the expectations as discussed in Chapter II. From the aspect of circadian rhythms, one would expect performance at night to be lower than during the day.

Several masking factors may account for this reversal. First, the average message load was higher during the day watches that at night. Although the performance data was normalized (Section A of Chapter V) to indicate percent errors, no account was made for message load (i.e., workload). It was pointed out in Chapter II that measures of performance were more accurate at higher levels of workload (slack time and the effects of variations in workload are reduced). The higher workload during the day (as measured by message load) therefore would create a more taxing, higher stressful environment in which to work--thus resulting in the decreased performance.

Next, a significant factor which varied between day and night was the amount of contact with individuals outside of the watch section. A number of individuals, both RM's and officers, perform administrative and operational support functions during the day (normally 0800 to 1600). This group of non-watchstanders interacts almost exclusively with the day watches as compared to night. This interaction results in several phenomena:

- higher personnel traffic in and out of the communication center.
- a higher noise level within the communication center.
- more demands placed on the watchstanders (by the dayworkers) to perform administrative/operational work or assist in projects in addition to the normal work to maintain the watch.

The survey was invaluable in discovering some of these related issues. While the survey was not designed to elicit any particular response on the dayworker activity and their interactions with the watchstanders, nine questionaires (24%) contained 'written-in' comments on this topic. These comments fell into two categories:

- criticism and harassment from the dayworkers that "watchstanders had an easy schedule."
- preferences to stand watch at night or on weekends to avoid contact with the dayworkers.

One individual included with his/her survey an itemized breakdown of hours worked for an entire year. The calculations compared work time for dayworkers versus watchstanders. According to his/her analysis, watchstanders work at least 156 hours more per year than dayworkers. This value was not recalculated by this author, but rather the fact that an individual took the time to perform the computations indicates that the individual felt strongly about the subject area and wished to respond to dayworker comments of an "easy schedule".

It is very relevant but quite impossible to discern the source of the differences between the four watch sections. Since this study did not intend to compare the activities between watch sections, it is difficult to make more accurate interpretations of these results without further investigation.

In support of the research from Chapter 2, Questions 15 and 16 indicate that the majority of the watchstanders maintain a 'DAY routine' during time-off (73.0% during the 72-hour break, 59.5% during the 96). Many of the remaining persons indicated slight modifications to this basic routine (e.g., sleep half-day on the first day after N3, take afternoon nap before N1). Thus most of the workers are able to maintain a normal diurnal schedule for 75% of the time. This would imply that the watchstanders are adapted for higher performance during the DAY watches than the NIGHT watches.

B. LOCATION-WITHIN-WATCH PERFORMANCE

The only significant results from the data for location-within-watch performance focused on the DAY watches. Performance was lower in the THIRD period than in the SECOND period, which was also lower than the FIRST period. These results are not surprising, considering the long twelve-hour watches which are stood. First of all, it has already be pointed out that the workload during DAYS is higher that NIGHTS. This may have a tendency to increase the effects of fatigue through the watch.

In support of the literature, Question 17 found that the highest fatigue was felt by the workers in the last four hours of the watch, while the lowest fatigue was felt in the first four hours.

C. CYCLE LOCATION PERFORMANCE

The performance data revealed no significant increases nor decreases within the DAY (D1 → D2 → D3) or NIGHT (N1 → N2 → N3). None of the survey questions were designed to provide any assistance in this evaluation.

D. OTHER

While indirectly linked to performance evaluation, the survey revealed several major points which must be considered by supervisors when considering shiftwork schedules.

1. Almost three-fourths of the watchstanders desire to stand 12-hour watches. The negative aspects (irregular sleep, effects on family/social life, poor eating habits, etc.) are more than compensated for by the major positive aspect--extended time off. Radioman will work long, hard hours to achieve extraordinary liberty time.

2. Additionally, seven survey responses (18%) included complaints on having to perform training and inspections during 'time-off'. These individuals felt that this created an additional burden to their already-strained schedules, and provided a negative impact on morale. One particular recent training session, a defensive driving course, was directly cited as having a negative impact on morale and satisfaction.

Due to the real-time operations within the communications center, it is quite evident that training, inspections, etc. can not occur during duty-time. The only time for such activities is during the specified 'time-off' periods. In this regard, the only recommendation to be made is that every effort should be made to ensure that the inconveniences are minimized and distributed evenly among the four watch sections. Suggestions that such training and inspections be held on weekends are ludicrous and unsupportable, since the only effect of this would be to create additional inconvenience for the dayworkers without alleviating any problems of the watch sections.

Nevertheless, the existence of training, inspections, etc. may create ill-feelings among some of the watchstanders for the dayworkers. As a result, they may desire to further isolate themselves from the non-watchstanders by prefering to stand NIGHT or weekend watches. This may be reflected in Question 14 of the survey. The answers to this question indicate that 38.5% of the watchstanders would rather stand 'Night watches only' and 3.1% would prefer to stand 'DAYS on weekends/NIGHTS on weekdays.'

VIII. SUMMARY

A. CONCLUSIONS

The conclusions of this study are in reference to the three basic research questions from Chapter I.

1. Day versus Night

The first hypothesis of this thesis was that performance during DAY watches will be higher that that of during NIGHT watches. This is generally refuted by the results of this study. Performance between the DAY and NIGHT watches is not significantly different with the exception of the FIRST four hours which exhibit higher performance during the DAY than at NIGHT. Other variations which exist between DAY and NIGHT watches among watch sections may possibly be attributed to message load and interaction with non-watchstanding personnel.

2. Location Within Watch

The second hypothesis was that performance will decrease as the time on watch increases. This was supported only for DAY watches, and is not upheld for NIGHT watches. Performance within a given watch declines as time on watch increased for the DAY watches. No significant decrease in performance was noticeable on NIGHT watches.

3. Cycle Location

The last hypothesis was comprised of two parts: first, performance differences between watches D1, D2, and D3 will not be significant; second, performance on the NIGHT watches will decrease as the night watches progress (N1 → N2 → N3). Both of these are refuted. Performance does not significantly change among the DAY (D1 → D3) nor the NIGHT (N1 → N3) cycles.

B. RECOMMENDATIONS

For improvements on this study, several recommendations are made. First, the measures of performance should be reviewed for their accuracy. If more comprehensive and accurate measures can be configured by the Communications Watch Officers or the Radiomen-in-Charge, then they should be implemented. Second, if this study is ever repeated, the performance data collection should extend for a longer period of time to obtain a larger sample size, thereby increasing the accuracy and significance of the results.

To enable a communications station to operate under an optimal watch schedule, it is quite obvious that numerous factors must be considered. The supervisors at the COMMSTAs should understand the interactions of circadian rhythms and shiftwork. In particular, the recommendations contained in Chapter II, Section G may offer applicable advice.

Finally, it must be realized that attempts to maximize performance will do so only at the expense of other factors. Ideally, the operation and administration of any Coast Guard station satisfies two requirements--one, to perform the services expected by the public and private sectors of the community, and, two, to provide and care for its major resource, the men and women of the Coast Guard. This balance must be kept in mind when designing watch schedules.

APPENDIX A
DATA COLLECTION FORMS

DATE SECTION

Time	Improp. Stamped	Non-D	Msg Sent Incomp/ Garbled	Missing SVC Cross	Misfiled	CIMs	Other	Total
0600-1000								
1000-1400								
1400-1800								
Total								

Total Number of Messages Processed ____

Preparation Date ________ Time _____ Initials _____

DATE SECTION

Time	Improp. Stamped	Non-D	Msg Sent Incomp/ Garbled	Missing SVC Cross	Misfiled	CIMs	Other	Total
1800-2200								
2200-0200								
0200-0600								
Total								

Total Number of Messages Processed ____

Preparation Date _________ Time _____ Initials _____

APPENDIX B
PERFORMANCE DATA

Day	Cycle	Watch Section	% of Messages in Error First	Second	Third	Total	Total Number of Msgs Processed
01	D1	A	02.61	00.00	05.22	02.61	115
01	N1	B	04.17	00.00	00.00	01.39	72
02	D2	A	00.00	02.08	00.00	00.69	144
02	N2	B	02.73	08.18	02.73	04.55	110
03	D3	A	00.00	16.15	11.54	09.23	130
03	N3	B	02.54	07.63	05.08	05.08	118
04	D1	C	04.26	12.77	02.13	06.38	141
04	N1	D	24.42	13.95	03.49	13.95	86
05	D2	C	02.38	11.90	14.29	09.52	126
05	N2	D	02.42	00.00	04.84	02.42	124
06	D3	C	06.52	06.52	04.35	05.80	138
06	N3	D	02.21	02.21	06.62	03.68	136
07	D1	B	02.80	05.61	05.61	04.67	107
07	N1	A	00.00	04.23	04.23	02.82	71
08	D2	B	00.00	06.66	00.00	02.22	90
08	N2	A	00.00	00.00	12.16	04.05	74
09	D3	B	08.57	00.00	00.00	02.86	105
09	N3	A	03.12	00.00	00.00	01.04	96
10	D1	D	00.00	00.00	00.00	00.00	108
10	N1	C	06.90	00.00	03.45	03.45	87
11	D2	D	00.00	02.86	00.00	00.95	105
11	N2	C	03.37	03.37	00.00	02.25	89
12	D3	D	00.00	00.00	08.00	02.67	75
12	N3	C	03.53	03.53	07.06	04.71	85
13	D1	A	02.10	00.00	00.00	00.70	143
13	N1	B	00.00	03.03	03.03	02.02	99
14	D2	A	00.00	00.00	00.00	00.00	106
14	N2	B	00.00	12.33	00.00	04.11	73
15	D3	A	00.00	02.52	02.52	01.68	119
15	N3	B	00.00	00.00	00.00	00.00	62
16	D1	C	00.00	06.34	04.23	03.52	142
16	N1	D	00.00	02.61	15.65	06.09	115
17	D2	C	02.91	05.83	08.74	05.83	103
17	N2	D	00.00	00.00	00.00	00.00	88
18	D3	C	02.36	00.00	07.09	03.15	127
18	N3	D	02.65	02.65	02.65	02.65	113

		Watch	% of Messages in Error				Total Number of
Day	Cycle	Section	First	Second	Third	Total	Msgs Processed
19	D1	B	00.00	09.28	06.19	05.15	97
19	N1	A	02.88	02.88	00.00	01.92	104
20	D2	B	02.73	10.91	00.00	04.55	110
20	N2	A	00.00	00.00	00.00	00.00	82
21	D3	B	00.00	00.00	10.71	03.57	56
21	N3	A	00.00	04.23	04.23	02.82	71
22	D1	D	04.23	08.45	04.23	05.63	142
22	N1	C	10.00	00.00	00.00	03.33	60
23	D2	D	00.00	03.87	03.87	02.58	155
23	N2	C	03.75	00.00	11.25	05.00	80
24	D3	D	00.00	00.00	06.98	02.33	86
24	N3	C	07.50	00.00	07.50	05.00	80
25	D1	A	00.00	03.19	09.57	04.26	94
25	N1	B	10.00	00.00	00.00	03.33	60
26	D2	A	05.66	02.83	02.83	03.77	106
26	N2	B	04.29	08.57	00.00	04.29	70
27	D3	A	00.00	04.05	12.16	05.41	74
27	N3	B	03.75	07.50	00.00	03.75	80
28	D1	C	02.56	10.26	12.82	08.55	117
28	N1	D	00.00	04.55	00.00	01.52	66
29	D2	C	06.12	06.12	06.12	06.12	98
29	N2	D	12.50	00.00	06.25	06.25	48
30	D3	C	00.00	08.11	12.16	06.76	74
30	N3	D	00.00	00.00	00.00	00.00	95
31	D1	B	03.09	03.09	06.19	04.12	97
31	N1	A	00.00	06.59	03.30	03.30	91
32	D2	B	00.00	08.91	14.85	07.92	101
32	N2	A	23.68	11.84	00.00	11.84	76
33	D3	B	00.00	06.98	48.84	18.60	86
33	N3	A	00.00	00.00	00.00	00.00	86
34	D1	D	02.65	00.00	00.00	00.88	113
34	N1	C	10.17	00.00	05.08	05.08	118
35	D2	D	02.24	02.24	08.96	04.48	134
35	N2	C	08.57	00.00	04.29	04.29	70
36	D3	D	00.00	00.00	01.69	00.56	177
36	N3	C	10.71	10.71	00.00	07.14	56

'First' = first four hours of watch
'Second' = middle four hours of watch
'Third' = last four hours of watch
'Total' = entire 12 hour watch

APPENDIX C
SAMPLE SURVEY

RM QUESTIONAIRE

This questionaire is part of a thesis research project I am doing at the Naval Postgraduate School in Monterey, California. I am currently completing a Master's Program in Telecommunications Systems Management, and this thesis is the final project to meet the requirements for the degree.

At many Coast Guard stations we inevitably stand watches, in one form or another. The RM rating is especially peculiar with the long 12-hour watches that are maintained at many COMMSTAs. This questionaire concerns watchstanding schedules and your opinions about standing such watches.

This study, however, is not an indication of an upcoming change in your existing watch schedule. Your watches are set up by the supervisors at your own COMMSTA. This survey is, by no means, an attempt to influence their decisions or to initiate any change in your watch schedule.

Additionally, the questionaire will not be used to evaluate your individual performance, or that of your watch section or COMMSTA.

Once the entire research project is completed, the results will be distributed to each Coast Guard Communication Station. The report will be available to any RM who wishes to read it. Hopefully, the results will provide some insight and guidance to you and your supervisors to aid in the future design of your watch schedules and in the understanding of your motivation and opinions.

To maintain your privacy, your responses to this survey will be held confidential and will only be used for this study. To ensure the privacy of your answers, I have provided an envelope for each individual survey. Once you have complete the questionaire, place it back in the envelope and seal the flap. Do not write your name or any other information on the outside of the envelope. Then place the sealed envelope in the box provided.

Thank you for your time in completing this survey. Should you have any questions or comments about this survey and my research project, please call me (Work: 408-646-2056; Home: 408-372-5084).

David C. Ely, LTJG, USCG

INSTRUCTIONS

1. This is not a test--there are no right or wrong answers. You should answer the questions the way you feel personally, the way things seem to you. Your frankness is invaluable to this study.

2. When you answer the questions, think about all of the watches you have stood during your time at the COMMSTA. Try not to single out any one particular watch (be it good or bad).

3. If you don't find the exact answer that fits your case, choose the one that comes closest to it.

4. If no other specific instructions are given, CIRCLE the best answer.

5. Feel free to write in any comment or explanation you may have.

6. The survey should take approximately 10 minutes to complete.

Questions 1 thru 5 are for general information.

---

1. Fill-in

   Rate ____ COMMSTA __________

   Months at COMMSTA ____ Today's Date _________

   Watch Section ____ Time (local) _____

2. How long does it normally take you to commute to work (one way) ?
   a. less than 5 minutes
   b. 5 to 15 minutes
   c. 15 to 30 minutes
   d. more than 30 minutes
3. Are you ?
   a. Single/Widowed
   b. Married
   c. Divorced/Separated
4. Are you ?
   a. Female
   b. Male
5. What type of watch are you currently standing ?
   a. Day (0645-1845)
   b. Night (1845-0645)

Questions 6 thru 16 are concerned with shiftwork and watchstanding in general.

---

6. What 2 items do you most dislike about shiftwork ? (Rank your top two choices: 1 = highest dislike, 2 = second highest dislike)

   _____ effects on social life
   _____ irregular sleeping times
   _____ working at night
   _____ irregular meal times
   _____ early rising
   _____ effects on family life
   _____ effects on health
   _____ other ______________________________
   (please write in)
   _____ no dislikes

7. What effect has shiftwork had on your health?

   a. Good
   b. None
   c. Bad

   If "Good" or "Bad", what effect ? ____________________
   ____
   ____

8. Has shift working had any other important effect?

   a. Good
   b. None
   c. Bad

   If "Good" or "Bad", what effect ? ____________________
   ____
   ____

9. In your opinion, what are the positive aspects of your watch schedule?

   ____
   ____
   ____

10. In your opinion, what are the negative aspects of your watch schedule?

   ____
   ____
   ____

11. Are you satisfied with the existing watch schedule?

   a. Yes
   b. Partially
   c. No

12. Would you like to see some changes made in the watch schedule?

a. Yes
b. No

If "Yes" to the above question, what kind of changes would you like to see occur, and why?

____
____
____

13. If you had a choice, which length of watch would you rather stand (assuming that you'd maintain the four duty sections) ?

a. 6-hr watches
b. 8-hr watches
c. 12-hr watches
d. Other ______________________________
____

Why ? ______________________________
____
____

14. Given that you would continue to stand 12-hour watches, if you had to make a choice, which would you rather stand ? (Rank your top two choices: 1 = highest, 2 = second highest)

_____ Night watches only
_____ Day watches only
_____ A combination of Day and Night watches
_____ Other ______________________________
____

15. In the <u>72-hr</u> break between DAY and NIGHT watch cycles what routine do you usually maintain ?

a. normal day routine (active during day, sleep at night)
b. night routine (active at night, sleep during day)
c. other ______________________________
____

16. In the <u>96-hr</u> break between NIGHT and DAY watch cycles what routine do you usually maintain ?

a. normal day routine (active during day, sleep at night)
b. night routine (active at night, sleep during day)
c. other ______________________________
____

Questions 17 thru 19 are concerned with your activities during the 12-hour watch.

---

17. Please rank the following time intervals in order of fatigue you feel while on watch (1 = highest, 2 = moderate, 3 = lowest fatigue).

    _____ first 4 hours
    _____ middle 4 hours
    _____ last 4 hours

18. Do you get a 'second wind' during your watches?

    a. very frequently
    b. frequently
    c. occasionally
    d. rarely
    e. never

    If you do get a second wind, at what point in the watch do you usually get it ? ______________________________

    ____

19. If you do feel tired, fatigued, or sleepy on watch, what do you do to combat it and remain alert ? (Rank your top two choices: 1 = highest, 2 = second highest)

    _____ drink coffee/soda, or eat candy/snacks, etc.
    _____ rotate among duties/stations within the COMMCENTER
    _____ try to keep busy, work on projects, training, etc.
    _____ stretch, perform light exercise, isometrics, etc.
    _____ take rest breaks, etc.
    _____ other ______________________________

    ____

    _____ I never feel tired, fatigued, etc. while on watch

APPENDIX D
SURVEY RESULTS--COMMSTA SAN FRANCISCO

QUESTION 1: What is your rate?

Rate (n = 38)	Freq.	Percent
E-4	14	41.2
E-5	7	20.6
E-6	11	32.4
E-7	2	5.9
NR	4	----

QUESTION 2: How long does it normally take you to commute to work (one way)?

Commute Time (n = 38)	Freq.	Percent
less than 5 min.	0	0
5 to 15 min.	0	0
15 to 30 min.	18	47.4
more than 30 min.	20	52.6

QUESTION 3: Are you?

Marital Status (n = 38)	Freq.	Percent
Married	23	60.5
Single/Widowed	12	31.6
Divorced/Separated	3	7.9

QUESTION 4: Are you?

Sex (n=38)	Freq.	Percent
Female	9	23.7
Male	29	76.3

QUESTION 5: What type of watch are you currently standing?

Watch (n=40)	Freq.	Percent
Day	37	92.5
Night (Mid)	1	2.5
*Dayworker	2	5.0

QUESTION 6: What items do you most dislike about shiftwork?

Dislikes (n=69)	Freq.	Percent
Irregular sleeping habits	17	24.6
Effects on family life	17	24.6
Effects on social life	9	13.0
Early rising	9	13.0
Effects on health	6	8.7
Working at night	4	5.8
Irregular meal times	2	2.9
*Difficult to attend advanced education	2	2.9
*Complaints/harassment from dayworkers	2	2.9
*Missing holidays frequently	1	1.4
No dislikes	5	7.2

QUESTION 7: What effect has shiftwork had on your health?

Effect on Health (n=38)	Freq.	Percent
Good	1	2.7
None	18	48.6
Bad	18	48.6
NR	1	----

If "Good", what effect?

Good Health Effects (n=1)	Freq.	Percent
NR	1	----

If "Bad", what effect?

Bad Health Effects (n=32)	Freq.	Percent
*Irregular sleeping habits	11	34.4
*Indigestion/poor eating habits	8	25.0
*No regular exercise	3	9.4
*Stress, headaches	3	9.4
*Long recuperations from illness	2	6.2
*Weight loss	1	3.1
*Effects of Coffee/Nodoze	1	3.1
*Difficult to diet	1	3.1
*Prematurely aging	1	3.1
*Bags under eyes	1	3.1

QUESTION 8: Has shift working had any other important effect?

Other Effects (n=38)	Freq.	Percent
Good	5	13.5
None	20	54.1
Bad	12	32.4
NR	1	----

If "Good", what effect?

Good Effects (n=5)	Freq.	Percent
*Extended time off	3	60.0
*Able to get part-time job	1	20.0
*Do personal business during week	1	20.0

If "Bad", what effect?

Bad Effects (n=11)	Freq.	Percent
*Miss holidays frequently	3	27.3
*Schedule juggling w/family & friends	2	18.2
*Fall asleep at wheel during drive home	2	18.2
*Stores/offices closed during free time	1	9.1
*Can't do admin paperwork at station	1	9.1
*Divorce	1	9.1
*Complaints/harassment from dayworkers	1	9.1

QUESTION 9: In your opinion, what are the positive aspects of your watch schedule

Positive Aspects (n=38)	Freq.	Percent
*Extended time off	27	71.1
*Fewer watch reliefs	3	7.9
*Perform personal business weekdays	3	7.9
*Able to get part-time job	2	5.3
*Fewer long commutes	1	2.6
*Watches w/o non-radiomen	1	2.6
*No crowds in public during week	1	2.6
*Watch section comraderie	1	2.6
NR	4	----

QUESTION 10: In your opinion, what are the negative aspects of your watch schedule?

Negative Aspects (n=45)	Freq.	Percent
*Training/inspections on off-time	5	14.3
*Difficult to attend advanced education	5	14.3
*Few free weekends/month	4	11.4
*Switching from days to nights	4	11.4
*Complaints/harassment from dayworkers	4	11.4
*Irregular sleeping habits	3	8.6
*Lack of comms/hot word passing at station	2	5.7
*Juggling family/social schedules/plan events	2	5.7
*Early rising for day watches (0300-0400)	2	5.7
*Switching from nights to days	2	5.7
*Having to work weekdays	1	2.9
*High amount of work per person	1	2.9
NR	10	----

QUESTION 11: Are you satisfied with the existing watch schedule?

Satisfaction (n=38)	Freq.	Percent
Yes	14	37.8
Partially	16	43.2
No	7	18.9
NR	1	----

QUESTION 12 Would you like to see some changes made in the watch schedule?

Changes (n=38)	Freq.	Percent
Yes	29	76.3
No	9	23.7

If "Yes", what kind of changes would you like to see?

Changes (n=30)	Freq.	Percent
*5 watch sections	17	56.7
*Month of mids/month of days, etc.	7	23.3
*8-hour watches	5	16.7
*Week of mids/week of days, etc.	1	3.3

QUESTION 13 If you had a choice, which length of watch would you rather stand (assuming that you'd maintain the four duty sections)?

Length (n=38)	Freq.	Percent
6-hr watches	0	0.0
8-hr watches	11	28.9
12-hr watches	27	71.1
NR	1	----

QUESTION 14 Given that you would continue to stand 12-hour watches, if you had to make a choice, which would you rather stand?

Choice (n=65)	Freq.	Percent
Night watches only	25	38.5
Combination of days and nights	22	33.8
Day watches only	16	24.6
*Days on weekends/nights on weekdays	2	3.1

QUESTION 15: In the 72-hour break between DAY and NIGHT watch cycles, what routine do you usually maintain?

72-hour break (n=38)	Freq.	Percent
Day routine	27	73.0
Night routine	5	13.5
*Stay up late at night/sleep late in the day	2	5.4
*Sleep late in the day	1	2.7
*Stay up late at night	1	2.7
*Afternoon nap before first mid	1	2.7
NR	1	----

QUESTION 16: In the 96-hour break between NIGHT and DAY watch cycles, what routine do you usually maintain?

96-hour break (n=38)	Freq.	Percent
Day routine	22	59.5
Night routine	4	10.8
*First day off--sleep half day	4	10.8
*Stay up late at night/sleep late in the day	3	8.1
*First day off--sleep all day	2	5.4
*Active day and night	1	2.7
*Stay up late at night	1	2.7
NR	1	----

QUESTION 17: Please rank the following time intervals in order of fatigue you feel while on watch.

Highest Fatigue (n=38)	Freq.	Percent
First 4 hours	3	8.1
Middle 4 hours	12	32.4
Last 4 hours	22	59.5
NR	1	----

Moderate Fatigue (n=38)	Freq.	Percent
First 4 hours	9	25.7
Middle 4 hours	17	48.6
Last 4 hours	9	25.7
NR	3	----

Lowest Fatigue (n=38)	Freq.	Percent
First 4 hours	22	66.7
Middle 4 hours	6	18.2
Last 4 hours	5	15.2
NR	5	----

QUESTION 18: Do you get a 'second wind' during your watches?

Second Wind (n = 38)	Freq.	Percent
Very frequently	8	21.1
Frequently	8	21.1
Occasionally	18	47.4
Rarely	4	10.5
Never	0	0.0

If you do get a second wind, at what point in the watch do you usually get it?

When (n = 34)	Freq.	Percent
*10th to 12th hour	9	23.5
*9th to 10th hour	6	17.6
*7th to 9th hour	6	17.6
*Halfway thru the watch	5	14.7
*When I get busy	5	14.7
*No specific time/it varies	4	11.8

QUESTION 19: If you do feel tired, fatigued, or sleepy on watch, what do you do to combat it and remain alert?

Activity (n = 75)	Freq.	Percent
Drink soda, coffee, or eat, etc.	29	38.7
Keep busy, work on projects, training, etc.	14	18.7
Stretch, exercise, walk around	13	17.3
Rotate among duties/positions	10	13.3
Take rest breaks	4	5.3
*Read/study courses, COMDT Bulletin, etc.	2	2.7
*Take Nodoze/Vivarin	1	1.3
I never feel tired, fatigued while on watch	2	2.7

APPENDIX E
SURVEY RESULTS--COMMSTA PORTSMOUTH

The presentation of the survey is similar to the previous appendix. Questions 15 and 16 were discarded because they were erroneously worded for the particular watch schedule at COMMSTA Portsmouth.

QUESTION 1: What is your rate?

Rate (n=38)	Freq.	Percent
E-4	13	41.9
E-5	10	32.3
E-6	4	12.9
E-7	4	12.9
NR	7	----

QUESTION 2: How long does it normally take you to commute to work (one way)?

Commute Time (n=37)	Freq.	Percent
less than 5 min.	17	45.9
5 to 15 min.	5	13.5
15 to 30 min.	10	27.0
more than 30 min.	5	13.5

QUESTION 3: Are you?

Marital Status (n=37)	Freq.	Percent
Married	25	67.6
Single/Widowed	9	24.3
Divorced/Separated	3	8.1

QUESTION 4: Are you?

Sex (n=37)	Freq.	Percent
Female	7	18.9
Male	30	81.1

QUESTION 5: What type of watch are you currently standing?

Watch (n=38)	Freq.	Percent
Day	20	52.6
Night (Mid)	17	44.7
*Dayworker	1	2.6

QUESTION 6: What items do you most dislike about shiftwork?

Dislikes (n=63)	Freq.	Percent
Irregular sleeping habits	16	25.4
Effects on health	9	14.3
Irregular meal times	8	12.7
Effects on social life	7	11.1
Effects on family life	5	7.9
Working at night	5	7.9
Early rising	4	6.3
*Missing holidays/weekends frequently	1	1.6
*Difficult to attend advanced education	1	1.6
*No regular exercise time	1	1.6
*Unable to attend station picnics/sports	1	1.6
No dislikes	5	7.9

QUESTION 7: What effect has shiftwork had on your health?

Effect on Health (n=37)	Freq.	Percent
Good	0	0.0
None	21	56.8
Bad	16	43.2

If "Good", what effect?

Good Health Effects (n=0)	Freq.	Percent
NR	0	----

If "Bad", what effect?

Bad Health Effects (n=27)	Freq.	Percent
*Irregular sleeping habits	6	22.2
*Fatigue, lack of energy	6	22.2
*Indigestion/poor eating habits	4	14.8
*No regular exercise	3	11.1
*Weight gain/difficult to diet	3	11.1
*Stress, headaches, anxiety, low tolerance	3	11.1
*Long recup. from illness/get sick easy	2	7.4

QUESTION 8: Has shift working had any other important effect?

Other Effects (n=36)	Freq.	Percent
Good	2	5.9
None	27	79.4
Bad	5	14.7
NR	2	----

If "Good", what effect?

Good Effects (n=3)	Freq.	Percent
*Extended time off	2	66.7
*Able to get part-time job	1	33.3

If "Bad", what effect?

Bad Effects (n=4)	Freq.	Percent
*Burn-out	2	50.0
*Can't keep track of days/time	1	25.0
*Difficult schedule with baby at home	1	25.0

QUESTION 9: In your opinion, what are the positive aspects of your watch schedule

Positive Aspects (n=44)	Freq.	Percent
*Extended time off	29	69.0
*No crowds in public during week	3	7.1
*Perform personal business weekdays	3	7.1
*Able to get part-time job	2	4.8
*Watch section comraderie	2	4.8
*Able to get away from spouse	1	2.4
*Able to continue advanced education	1	2.4
*None	1	2.4
NR	2	----

QUESTION 10: In your opinion, what are the negative aspects of your watch schedule?

Negative Aspects (n=35)	Freq.	Percent
*Irregular sleeping habits	8	22.9
*Training/inspections on off-time	3	8.6
*Switching/adjusting from nights to days	3	8.6
*Fatigue/difficult to stay awake	3	8.6
*Long watches	2	5.7
*Too few people in sections for leave	2	5.7
*Juggling family/social schedules/plan events	2	5.7
*Difficult to attend advanced education	2	5.7
*Switching/adjusting from days to nights	2	5.7
*Too many watches in a row	1	2.9
*Few free weekends/month	1	2.9
*Lack of command unity, pride in job	1	2.9
*None	4	11.4

QUESTION 11: Are you satisfied with the existing watch schedule?

Satisfaction (n= 37)	Freq.	Percent
Yes	20	54.1
Partially	15	40.5
No	2	5.4

QUESTION 12 Would you like to see some changes made in the watch schedule?

Changes (n= 37)	Freq.	Percent
Yes	11	29.7
No	26	70.3

If "Yes", what kind of changes would you like to see?

Changes (n= 9)	Freq.	Percent
*2 Days/2 Mids, etc.	3	33.3
*5 watch sections	2	22.2
*8-hour watches (2-2-2-80)	1	11.1
*Month of mids/month of days, etc.	1	11.1
*Week of mids/week of days, etc.	1	11.1
*Later start of watch--0800/2000	1	11.1

QUESTION 13 If you had a choice, which length of watch would you rather stand (assuming that you'd maintain the four duty sections)?

Length (n = 37)	Freq.	Percent
6-hr watches	0	0.0
8-hr watches	4	10.8
12-hr watches	33	89.2

QUESTION 14 Given that you would continue to stand 12-hour watches, if you had to make a choice, which would you rather stand?

Choice (n = 61)	Freq.	Percent
Combination of days and nights	25	41.0
Day watches only	22	36.1
Night watches only	14	23.0

QUESTION 17: Please rank the following time intervals in order of fatigue you feel while on watch.

Highest Fatigue (n=36)	Freq.	Percent
First 4 hours	4	12.1
Middle 4 hours	7	21.1
Last 4 hours	22	66.7
NR	3	----

Moderate Fatigue (n=36)	Freq.	Percent
First 4 hours	2	6.1
Middle 4 hours	24	72.3
Last 4 hours	7	21.2
NR	3	----

Lowest Fatigue (n=35)	Freq.	Percent
First 4 hours	26	81.3
Middle 4 hours	2	6.2
Last 4 hours	4	12.5
NR	3	----

QUESTION 18: Do you get a 'second wind' during your watches?

Second Wind (n=37)	Freq.	Percent
Very frequently	5	13.5
Frequently	15	40.5
Occasionally	9	24.3
Rarely	4	10.8
Never	4	10.8

If you do get a second wind, at what point in the watch do you usually get it?

When (n=27)	Freq.	Percent
*Last four hours	7	25.9
*10th to 12th hour	7	25.9
*When I get busy	6	22.2
*Halfway thru the watch	4	14.8
*9th to 10th hour	1	3.7
*7th to 9th hour	1	3.7
*No specific time/it varies	1	3.7

QUESTION 19: If you do feel tired, fatigued, or sleepy on watch, what do you do to combat it and remain alert?

Activity (n=68)	Freq.	Percent
Drink soda, coffee, or eat, etc.	29	43.3
Keep busy, work on projects, training, etc.	19	28.4
Stretch, exercise, walk around	10	14.9
Rotate among duties/positions	3	4.5
*Talk to other watchstanders	3	4.5
*Use will power	1	1.5
*Smoke	1	1.5
I never feel tired, fatigued while on watch	1	1.5
NR	1	----

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